CASEOUS NODULES OF THE LUNG.

OBSERVATIONS ON TWENTY-FIVE CASES TREATED BY RESECTION.

VOLUME I - TEXT.

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INTRODUCTION.

The term "caseous nodule" defines a localised encapsulated area of tuberculous disease, essentially of a solid nature and consisting, for the most part, of caseous debris.

The occurrence of these caseous nodules in the lungs of persons suffering from pulmonary tuberculosis has been known for many years. There has been much speculation as to their etiology and behaviour and much divergence of opinion as to the methods which should be employed in their treatment.

Some of the radiographic appearances of this type of disease are well known. They are usually well defined, uniform opacities which are round or oval in shape and their solid nature can often be inferred from the radiographs. In the past they have been known at various times as tuberculomata, Assman's foci, round shadows, coin lesions and localised caseous pneumonias.

The object of this work is to examine the findings in a consecutive series of patients from whom specimens of caseous nodules were removed surgically, and to consider the relationship between the clinical course of the disease, the radiographic appearances and the morbid anatomy. The ultimate aim is to gain knowledge bearing on the differential diagnosis and prognosis

of these lesions, and thus obtain data on which a reasoned line of treatment may be founded.

The investigation has been made possible by the present enthusiasm for the operation of lung resection in the treatment of caseous nodules. An increasing number of resected specimens is becoming available for study and this material, for the most part, represents an earlier stage in the development of pulmonary tuberculosis than is seen in post-mortem examinations.

Resection of caseous nodules is at present undertaken because of their supposedly treacherous nature. Despite recent progress in operative technique and post-operative management, the operation of lung resection carries with it a significant mortality and morbidity. It is, therefore, of the greatest importance that the exact nature and behaviour of these nodules be investigated for only then can the possibility of their management by more conservative methods be properly assessed.

The intention is not to justify any particular line of treatment, but to present an unbiased study of the problem.

HISTORICAL CONSIDERATIONS.

The term "caseous nodule" is by no means a new one in the terminology of pulmonary tuberculosis. Caseation has long been recognised as a pathological process peculiar to tuberculosis and the finding of nodules in the lungs of persons dead of the disease occurred as long ago as the seventeenth century. Sylvius (1614-1672) is credited with first observing them and relating them to phthisis, although he regarded them as enlarged glands resulting from scrofula. He knew, however, that they could break down to form cavities (Osler, 1909).

Many years later, in 1738, a Bordeaux physician named Desault showed that tuberculous nodules were not pathological variations of existing glands, but were actually new formations in the lung (Fowler, 1921a).

The next important observations on the tuberculous nodule came from a remarkable Englishman, Dr. William Stark (1788). Stark lived from 1740-1770 but his work was not published until eighteen years after his death. His writings on the particular subject under review are worth quoting in full:

"In the cellular substance of the lungs are found roundish, firm bodies (named tubercles) of different sizes from the smallest granule to about half an inch in diameter, the latter often in clusters.

"The tubercles of a small size are always solid, even those of a larger are frequently so; they are of a whitish colour, and of a consistence approaching nearly to the hardness of cartilage; when cut through, the surface appears smooth, shining and uniform. No vesicles, cells or vessels are to be seen in them, even when examined with a microscope after injecting the pulmonary artery and vein. On the cut surface of some tubercles were observed small holes, as if made by the pricking of a pin; in others were found one or more small cavities containing a thick white fluid like pus; at the bottom of each of these cavities when emptied, several small holes were to be seen, from which, on pressing the tubercle, matter issued; but neither these holes nor the others mentioned above (so far, at least, as could be determined) communicated with any vessels.

"The cavities in different tubercles are of different sizes, from the smallest perceptible to half an inch or three-quarters of an inch in diameter, and, when cut through and emptied, have the appearance of small white cups, nothing remaining of the substance of the tubercle except a thin covering or capsula. The cavities of less than half an inch diameter are always shut quite up; those which are a little larger have as constantly, a round opening made by a branch of the trachea.

"At this period, there being a free passage for the matter contained in the tubercle into the trachea and a communication between the cavity of it and the open air, it is proper to change the name of tubercle to that of vomica."

This passage illustrates Stark's remarkably accurate powers of observation. Even more amazing is the fact that before writing his paper, he made only ten post-mortem examinations on cases of phthisis. Unhappily, he succumbed to typhoid fever at the early age of twenty-nine.

Bayle (1810) too, noted tuberculous foci, some "as large as chestnuts" and observed that they need not be numerous, sometimes only two or three being present.

Laennec described (1819) miliary tubercles coalescing to form tubercles of a larger size and commented on the unusual finding of "encysted tubercles in an otherwise healthy and crepitous lung." He later described the not infrequent occurrence of "chalky or pultaceous masses, some as large as hazelnuts" and regarded them as tuberculous lesions in which nature had made an attempt at healing.

Buhl's contribution in 1857 is of some importance. It was that miliary tuberculosis frequently arose from a breaking-down caseous mass. One, at least, of the potential dangers of such a mass was thus emphasised.

This writer reported a case in which a caseous mass had been present in the lung for over forty years before it broke down and caused death from miliary tuberculosis in twenty-eight days (Fowler, 1921b).

Virchow (1864-1865) also described large nodules as resulting from agglomerations of smaller tubercles. He restricted the term tubercle to the miliary granule which had previously been described by Bayle and Laennec and regarded it as the unit from which larger nodules were constructed.

Birch-Hirschfeld (1882) described tuberculous cavities filled with "tough, thick material" and believed that such cavities were undergoing healing. He mentioned that "blockage of the secretion" played a part in their formation and that older inactive cavities "became enclosed in fibrous capsules". Birch-Hirschfeld was thus describing what are now called blocked cavities.

Kuss (1898), dealing with primary foci, mentioned that they may be caseous nodules often as large as hazelnuts and sometimes encapsulated.

A new phase in the study of pulmonary disease commenced with the advent of radiology and fresh insight into disease processes in the living subject was obtained. Caseous nodules were revealed on the

radiograph as round or oval opacities and so the more recent terms of "round foci" or "coin shadows" became popular.

The first important articles from the radiological point of view were thoseof Assman (1925 and 1930). He described a special variety of round focus, (which has since been called after him), occurring in the infraclavicular regions and thought by him to be a re-infection focus heralding incipient phthisis. He assumed that the morbid anatomical basis of the lesion was early tuberculous pneumonia of aerogenic origin and recognised that it could cavitate. He also called attention to small flecks arranged peripherally to the round focus, suggesting extension and most important of all pointed out that the more familiar picture of phthisis could develop by "aspiration metastases" although he was careful to add that all cases of phthisis may not develop in this way.

Despite the praise given to Assman, it is noteworthy that two years before, in 1923, Wessler and Jaches had described similar infraclavicular round lesions which they thought represented early pulmonary tuberculosis.

Consequently, by the twentieth century, four types

of caseous nodules were recognised.

1. Macroscopic aggregations of microscopic tubercles (tuberculoma).
2. Localised tuberculous pneumonia.
3. Blocked cavity.
4. Primary focus.

Great interest in the subject followed. In 1932 Straub reported ten cases which were all symptomless and accidentally discovered by radiography. He noted the stationary or slowly growing nature of the foci with associated lack of constitutional upset, absence of tubercle bacilli from the sputum and normal blood sedimentation rate. He also discussed at length the various courses that the lesions may take. Some may remain stationary for long periods, possibly breaking down at a later date, while some may get smaller and heal. Others may enlarge by concentric stratification. Many are the starting point of progressive pulmonary tuberculosis.

Bruck (1934) reported a case of multiple round foci which were distinguished from secondary malignant growths only with the greatest difficulty. In his discussion he agreed in many respects with the opinion of Straub, whom he quoted freely. Like Straub, too, he refuted the idea that round foci are often primary

because there is seldom an associated hilar gland enlargement.

Klein and Wolff (1934) added six more cases, five of which remained stationary for over two years, the sixth breaking down and terminating fatally in spreading exudative tuberculosis. At autopsy this lesion was found to consist of chalky, caseous substance at its centre and it was surrounded by a capsule. It was thought not to be a primary focus, and possibly to have had its origin in a bronchus.

In 1937, Birkelo and Kasper reported a radiological study of sixty cases of round shadow, some of which were proved, and the rest assumed, to be tuberculous. Most were followed for a year or more and the writers formed the opinion that the lesions represented a "benign" form of tuberculosis, in which healing by fibrous encapsulation was the outstanding feature. They segregated their cases into three radiological groups: (a) Foci which develop from a small area of infiltration. These are unstable and require watching. (b) Lesions which are circular when first observed. These are unlikely to become active. (c) Primary foci which subside satisfactorily. They do not report any pathological study.

Bobrowitz (1943) was of the opinion that round

foci were invariably the end-results of tuberculous cavitations. In all his cases in which the radiological history could be followed, a cavity was the antecedent of the round shadow. In his small group of cases which appeared to develop from minimal infiltrative shadows, he assumed that the intervening stage in their formation (that is, cavitation) occurred but was not seen on the radiographs. He considered caseous nodules to be a method of cavity healing but stated that, though usually benign, they are capable of further cavitation even after long periods of rest.

On the other hand, Sellors and Hickey (1949) thought they were unstable lesions which ought to be treated by resection. In addition, diagnostic difficulties and possible confusion with bronchogenic carcinoma was another important point in favour of early excision.

Mahon and Forsee (1950) agreed with this policy. In a study of forty-eight cases, they stated that nodules, which they called tuberculomata, may remain unchanged for years, but they emphasised their tendency to cavitate eventually. Furthermore, they claimed that there is no satisfactory medical treatment for this form of pulmonary tuberculosis and like Sellors and Hickey (1949) advocated resection, which in their

experience has become a relatively safe procedure.

By contrast, Moyes (1951) made a plea for a more optimistic outlook and conservative policy in treating caseous nodules. Thirty-one of his forty-one cases were alive and well at the end of the period of surveillance which extended from three to fifteen years. There were no deaths. Despite the good prognosis, 50% of the lesions showed evidence of instability at some time.

A more recent report on the subject by Pugh, Jones and Martin (1952) agrees largely with Moyes, while McLeod and Tait Smith (1952) have made an attempt to explain the behaviour of round foci in the light of their pathology as observed in resection specimens.

The present investigation is an attempt to enlarge upon the example of the latter writers, by considering more resected specimens and by reporting some features not emphasised by them.

THE PRESENT STUDY.

The investigation is based on twenty five cases of caseo-nodular pulmonary tuberculosis, who were patients in Pinewood Hospital, Wokingham, Berkshire.

All were eventually treated by lung resection and form a consecutive series of operations for this type of disease, carried out during the eighteen months from February 1952 until August 1953. Twenty patients were submitted to segmental resection, three to wedge resection and one to lobectomy. In all twenty five operations were done, one patient having a bilateral segmental resection, and so, twenty five specimens became available for pathological examination.

The clinical, radiographic and pathological manifestations of the disease are presented, followed by a discussion in which co-relation of the features of these three aspects of the disease is attempted.

Case histories with individual radiographic and pathological descriptions appear in the appendix.

Finally, a series of illustrations consisting of radiographs, photographs and photomicrographs are collected in a separate volume and reference will be made to them throughout the text.

CLINICAL ASPECTS.

AGE.

In this group of patients suffering from caseo-nodular disease, it was noted that the age incidence was closely similar to that of pulmonary tuberculosis in general. The average age was twenty-seven years, the youngest patient being eighteen and the oldest fifty-six. Table I shows the number of patients in each age group.

TABLE I AGE DISTRIBUTION. 24 PATIENTS.

Age Group	Below 20	20-29	30-39	40-49	50 or over	TOTAL
Number of Patients	4	12	7	0	1	24

Twenty-two of the twenty-four patients were between the ages of eighteen and thirty-five. This agrees with the findings of Moyes (1951).

SEX.

Twenty cases were females and four were males, but as this hospital admits predominantly female patients, the ratio given here is no true indication of the sex incidence. On the other hand, other writers have found females to be more commonly affected.

(Sellors & Hickey 1949; Moyes 1951; Pugh, Jones & Martin 1952).

FAMILY OR CONTACT HISTORY.

Ten (42%) patients gave a family or recent contact history of tuberculosis. When the diagnosis is in doubt and other evidence is lacking this factor may suggest the possibility of tuberculosis.

PAST HISTORY.

Fifteen (63%) of the patients had never had a serious illness in the past, one had had pleurisy ten years before, four gave a history of previous pneumonia, three of rheumatic fever and one of chorea. Past history, therefore, does not offer much diagnostic help.

SOCIAL CONDITIONS.

The poor environmental conditions which usually accompany tuberculosis were noticeably absent in this group. In only four cases was it possible to say that living conditions were really bad and that poor housing, inadequate income or poor mentality were obvious factors. Thirteen were well housed and belonged to the skilled artisan class. Six others had good incomes, four of these being professional people, while in one case the social conditions were unknown.

SYMPTOMATOLOGY

As is generally known, many of these lesions give rise to no symptoms. Thirteen (54%) were diagnosed either by mass radiography or picked up as contacts of a known case, and of these, eleven were completely symptomless and the other two were able only in retrospect to recall an occasional slight cough.

Cough, perhaps amounting to no more than a "tickle in the throat" with or without slight sputum, and fatigue were the commonest symptoms but others encountered less frequently were chest pain, loss of weight and haemoptysis.

Most of the patients with symptoms at the time of diagnosis rapidly became symptom-free after a few weeks of treatment and remained so on admission to hospital.

Conversely, some of the patients who had no symptoms when diagnosed, developed slight symptoms, usually productive coughs, while under observation.

PHYSICAL SIGNS.

Abnormal signs were often absent. Eleven patients had no abnormal findings in the chest and of the thirteen who had, persistent fine crepitations were audible in nine. The only other sign found with any frequency was increased dullness on percussion

over the affected areas. This was found in eight patients.

BLOOD SEDIMENTATION RATE.

In all cases the blood sedimentation rate (B.S.R.) was estimated by the Westergren method, a fall of less than 7 mm. per hour being taken as normal. Thirteen of the patients had a constant normal B.S.R. Four patients who presented with symptoms had a raised B.S.R. initially, but this returned to normal and remained so after a period of treatment. Seven patients showed some fluctuation in the B.S.R., the high readings always being associated with an increase in size of the lesion or a bronchogenic spread.

PRESENCE OF TUBERCLE BACILLI.

Sputum was rarely obtainable from these patients so that laryngeal swabs and gastric lavage cultures were used frequently for examination for tubercle bacilli. Regular positive results were not usually obtained. Five patients never had a positive result at any time and nine had only one positive swab or gastric lavage culture during the period of their investigation; of these seven were positive at the time of diagnosis and two became positive later. Ten cases were repeatedly but intermittently positive.

Table II summarises the positive findings in the

series.

TABLE II. PRESENCE OF TUBERCLE BACILLI. 24 PATIENTS.

Never positive at any time	ONE POSITIVE RESULT ONLY		Repeatedly but intermittently positive.
	Initially negative becoming positive	Initially positive becoming negative	
5	2	7	10

BRONCHOSCOPY.

Bronchoscopy was performed in fifteen cases. In twelve no abnormality was found and the other three had a trickle of mucopus exuding from the bronchus of the segment containing the disease. No evidence of endo-bronchitis or stenosis was discovered.

RADIOGRAPHIC APPEARANCES.

The radiographic appearances are described principally from posteroanterior films and from antero-posterior tomograms, although in certain cases, lateral films and lateral tomograms have been used. In a few instances bronchograms were done, but on the whole gave little information of value; this is probably because gross distortion of the bronchial tree is not a feature of localised caseo-nodular disease. In case 20, however, atelectasis of the apical and posterior segments of the right upper lobe was clearly seen by crowding of the bronchi in the bronchogram (Fig. 20d).

Caseous nodules cast distinctive radiographic shadows, but may be subject to considerable individual variation as regards shape, size density and multiplicity.

SHAPE.

The shadows in ten cases were round or nearly so. Caseous nodules are often referred to as "round foci". Nine others were roughly oval in shape while the remaining six were rather pleomorphic, so that the term "round focus" is not strictly accurate. In describing the shadows as round, oval or pleomorphic, these terms are used loosely.

The appearances of some shadows on the postero-anterior radiograph differed greatly from those on the tomogram. In case 1, for example, a round shadow on the ordinary film was revealed as an irregular opacity on the appropriate tomogram. Tomograms are therefore of considerably more value in gaining an accurate impression of the size and shape of the lesion: in addition they enable it to be localised. There should be no hesitation in taking tomograms of every lesion of this kind.

Although these shadows sometimes appeared as isolated opacities in an otherwise normal lung field (Fig. 10a), many lesions were surrounded by diffuse hazy shadows or scattered mottling (Figs. 2a, 6a, 8a, 11b, 17c and 20a).

The shape was also frequently influenced by associated linear, streaky or sometimes ill-defined shadows situated peripherally. These were interpreted as areas of local or sub-segmental atelectasis. The streaky or linear shadows, which often appeared as pseudopodia from the main body of the focus (Figs. 1b, 3b, 18b, 19b and 24a, b and c) were thought to represent fairly long-standing atelectasis, while the more ill-defined shadows (Figs. 2a, 6a and 20a, b and c) were thought to denote atelectasis of more

recent origin. In Figs. 5a (right) and 5c, the nodule is seen developing in a large wedge-shaped area of segmental atelectasis.

SIZE.

The average size of the shadows was 2.4 cm., the smallest being 1.5 cm. and the largest 4 cm. Smaller nodules of 1 cm. or less were frequently seen associated with the larger ones. These measurements were taken from tomograms where possible and in other cases from the postero-anterior films.

DENSITY.

Many shadows were revealed as having a uniform density but only two maintained this uniform density throughout their period of observation (Cases 10 and 21).

In the remaining twenty-three cases, an area of relative translucency was observed at some time within the shadow. In several cases, the translucency was rather ill-defined as seen for example in Figs. 1b, 2a, 3b and 6a, while in others, there was a distinct dividing line between the translucency and the remainder of the shadow (Figs. 5a left, 19c and 23c). In about one half of the cases, the area of translucency occurred at a fairly central position within the lesion and in the other half it appeared eccentrically.

The uniformity of density was disturbed, also, by

the presence of calcification, which was seen radiographically in five cases (1, 3, 4, 12 and 16). In case 4, the calcification was very marked, while in the others, it was deposited only in small flecks. In all these five cases in which calcification was present, areas of translucency co-existed.

MULTIPLICITY.

The shadows were seen to be single or multiple, occurring in one or both lung fields. Disregarding small nodules of less than 1 cm., solitary shadows were present in sixteen cases; two shadows were present in six cases and three shadows were seen in four cases. When multiple shadows developed close to each other, merging tended to occur and the number present was not clear. This was especially so on the ordinary film, but tomography clarified the picture by localising each lesion to the actual place which it occupied.

Multiple caseous nodules occurring in the same lung were not usually in the same state of activity, nor was there necessarily any similarity of shape, size or density between them. This is well shown by the three nodules in Fig. 5 left; the largest focus is fairly round and has a well marked central area of translucency; the larger of the two foci lateral to this is also round but of uniform density and the

smallest lesion is kidney-shaped and is calcified. Each nodule was thus accepted as representing an isolated process acting independently of other nodules, even though these were situated nearby in the same part of the lung.

SEGMENTAL DISTRIBUTION.

It was possible to localise the lesions fairly accurately by radiology.

Table III shows the segmental distribution in this series. It will be seen that in addition to the separate segments of the upper lobes, a column of the table has been devoted to the apical and posterior segments together. The cases in this latter group, which is by far the commonest, had fairly marked nodular disease in both segments and consequently both segments were removed at operation.

The figures in the table bear close resemblance to those obtained by Moyes (1951) and by Pugh, Jones & Martin (1952).

The right lung was more commonly affected than the left and the upper lobes more so than the lower. In this series and in Moyes' (1951) series the middle lobe and lingula were not involved but in the series of Pugh, Jones & Martin (1952) there were four cases with nodular lesions in the middle lobe.

TABLE III

SEGMENTAL DISTRIBUTION - 25 CASES.

LOBE	UPPER				LOWER			MIDDLE LOBE OR LINGULA	TOTAL
LUNG	ANTERIOR SEGMENT	POSTERIOR SEGMENT ALONE	APICAL SEGMENT ALONE	APICAL AND POSTERIOR SEGMENTS TOGETHER	APICAL SEGMENTS	LATERAL BASAL SEGMENT	OTHER BASAL SEGMENTS		
RIGHT	0	2	0	9	2	2	0	0	15
LEFT	1	3	1	5	0	0	0	0	10
TOTAL	1	5	1	14	2	2	0	0	25

The apical and posterior segments of the upper lobes were by far the commonest segments affected, accounting for twenty cases (80%) of the present group. These two segments were also much more frequently involved together than separately.

The anterior segment was attacked in only one case and in that, the lesion was situated in the axillary area of the segment.

"TRAMLINES".

This is a descriptive term which is applied to a radiographic feature of caseo-nodular disease. "Tramlines" were seen with great frequency in this series as pairs of parallel, linear or streaky shadows extending from the hilum to the caseous nodule. Sometimes seen in the ordinary postero-anterior film, they required tomography for clearer definition and to facilitate accurate interpretation. They represented, in the writer's opinion, pathological changes in bronchial walls, which had become infiltrated and thickened to a macroscopic degree by the tuberculous process. This observation was confirmed regularly by examination of the resected specimens. It is indeed surprising that the presence and significance of "tramlines" had not received more attention in the literature for they appear to be closely linked with the formation and

subsequent behaviour of the caseous nodules.

Normal bronchial walls are not visible radiographically except possibly when seen end-on and then they are seen as small ring shadows. Even tomographically, they are not normally visible and this had been confirmed by a study of normal tomograms, in which a main bronchus was visible (usually 7 cm., 8 cm. or 9 cm. cut). The lumen of the main bronchus can be seen as it transgresses the hilar shadow, but once beyond the periphery of the hilar shadow, it is no longer clearly seen. When "tramlines" are present, however, it is often possible to trace the continuity of the main bronchial lumen and lumina of smaller, more peripheral bronchi, contained within the "tramline" shadows.

It is not suggested that the presence of "tramlines" is peculiar to this form of pulmonary tuberculosis. Indeed, they are often seen in company with the more extensive shadowing of other forms of phthisis, although in these cases, they are given less attention as the bronchial disease is overshadowed by the parenchymatous disease.

In this series, eighteen cases showed definite evidence of "tramlines" and in the remaining seven cases their presence was doubtful. A very good example of

well-marked "tramlines" is seen in Fig. 19c, and other fairly good examples are shown in Figs. 5c, 6a and 16c.

ATELECTASIS.

The term atelectasis is used in its now accepted sense of collapse as opposed to its more literal meaning of failure to expand.

Mention of the radiographic appearance of atelectasis as seen in this study has already been made in describing how the shape of the nodules was often complicated by its presence.

In two cases (5 right and 16) the nodule developed within a wedge-shaped shadow representing a collapsed segment. In one other case (No. 20) segmental collapse was revealed in the bronchogram. Of the remaining twenty-two cases, thirteen presented some evidence of atelectasis, usually linear shadows distal to the nodule, as seen in Figs. 1b, 3b, 19b and 23a, b and c. In nine cases there was no clear evidence.

CAVITATION.

In twenty-three cases an area of increased translucency within the shadow was seen at some time.

It was, however, extremely difficult to prove that this radiological translucency meant that the nodule had established communication with a bronchus

and that an air-containing cavity had formed. This was so on account of the fact that invariably, several weeks elapsed between tomography of the lesion and its removal, an interval in which a change in the morbid anatomy could and sometimes did occur. In cases 14 and 19, there was definite pre-operative evidence of cavitation but the nodules were completely solid in the surgical specimens.

In case 9, a pre-operative diagnosis of cavitation within a nodule lesion was made, but the "cavity" proved to be an emphysematous bulla.

CALCIFICATION.

A search was made in every case for evidence of calcification not only within the nodules, but elsewhere in the chest, particularly the hilar glands.

In five cases, calcification was seen within the shadow and in fourteen others, it was seen elsewhere. Calcification is usually taken as evidence of an old and healing lesion, but in all five cases in which the nodule was partly calcified an area of translucency was also present, and a positive sputum was, at some time, obtained. In case 4, marked intranodular calcification was present and there was on two occasions, acute bronchogenic spread in the lower lobe.

RADIOLOGICAL CLASSIFICATION.

The development of the caseous nodules was studied as far as possible in serial radiographs.

In nine cases, the lesion was a fully formed nodule when first seen and no evidence was therefore available as to its mode of development.

In seven cases, a tuberculous cavity was seen in the first available radiograph, the later films showing a caseous nodule of similar size and shape to the antecedent cavity. This group was classified as blocked cavities.

In a further five cases, the original radiological finding was a very limited ill-defined opacity which was termed a "smudge". This "smudge" was observed in later flims to gradually enlarge and take on the characteristic appearance of a caseous nodule.

In the remaining four cases, the earlier radiographs showed a picture of exudative disease. It was only after the exudative disease cleared following treatment by chemotherapy, that the nodule became apparent.

The cases in the series therefore fell into two main radiological groups:-

A. Those in which the development was unknown, and

B. Those in which the development was observed.

Group B. contained three sub-groups:-

(1) Blocked cavities.

(2) Those gradually enlarging from minimal or "smudge" shadows.

and (3) Those emerging from a clearing area of exudative disease.

On this basis Table IV was compiled.

TABLE IV. RADIOLOGICAL CLASSIFICATION 25 CASES.

A. DEVELOPMENT UNKNOWN	B. DEVELOPMENT OBSERVED.		
Nodule on diagnostic radiograph	1) Blocked Cavities	2) Development from "smudge"	3) Emergence from exudative disease.
Case 1	Case 3	Case 5 (Left)	Case 12
Case 2	Case 11	Case 5 (Right)	Case 16
Case 4	Case 13	Case 6	Case 21
Case 7	Case 15	Case 8	Case 22
Case 9	Case 17	Case 14	
Case 10	Case 18		
Case 20	Case 19		
Case 23			
Case 24			
Total 9	7	5	4

This grouping was based on the appearance on the diagnostic radiograph, but when later films came to be examined, it was soon found that features of several groups appeared at different stages in the history of any one lesion.

For example, in case 20, a nodular lesion was present on the diagnostic film, but later radiographs showed that it cavitated and blocked before it was resected (Figs. 20a, b and c).

In case 12, diffuse shadowing was seen on the diagnostic film. This was observed to clear leaving nodular disease, which cavitated and blocked before it was resected.

A similar sequence of events also occurred in cases, 7, 8 and 22 so that in all, five cases not included in the blocked cavity group (B.1) went through this phase before having surgical treatment.

Case 19 showed a thick-walled cavity on the initial radiograph (Fig. 19a). This was observed to block (Fig. 19b), recavitate (Fig. 19c) and reblock (Fig. 19d) before being excised.

Case 14 is an example of a smudge shadow (Fig. 14a) which gradually developed into a nodule (Fig. 14b), later formed a cavity (Fig. 14c) which was resected and proved by the specimen (Fig. 14e) to have

blocked in the interval between the last tomogram and the operation.

These observations suggested that all these caseous nodules followed one pathological pattern in which a small initial lesion (causing a "smudge" shadow) grew into a nodule which might or might not cavitate and re-block to a variable extent.

It was also obvious that it was only possible to diagnose the type of nodule by serial radiographs and that in the absence of the latter, the radiographic features of all nodules were so similar as to defy distinction.

Table V gives in brief the radiological history of each case in the series and not only illustrates the inter-relationship between the various groups, but also indicates the various potential behaviour trends of caseous nodules.

TABLE V. RADIOLOGICAL HISTORY 25 CASES.

Case	Diagnostic Film	Intermediate Stages	Pre-operative Film.
1.	Nodule	Thought to be cavitating	Cavitating nodule.
2.	Nodule	Suspicion of cavitation.	Cavitating Nodule

TABLE V. Contd.

3.	Cavity in diffuse shadowing	Blocked under A.P. Re-opened under A.P. Re-blocked when A.P. was abandoned.	Blocked Cavity.
4.	Nodule	Cavitated giving rise to two bronchogenic spreads.	Cavitating Nodule.
5.	L. Smudge	Enlarged to form nodule which cavitated.	Cavitating Nodule
	R. Smudge	Enlarged (within atelectatic segment) to form nodule which cavitated.	Cavitating Nodule.
6.	Smudge	Enlarged to form nodule which cavitated.	Cavitating Nodule.
7.	Nodule	Cavitated then became solid again.	Blocked Cavity.
8.	Smudge	Enlarged and gave rise to exudative disease with a cavity which blocked.	Blocked Cavity.
9.	Nodule.	Thought to be cavitating.	Cavitating Nodule.
10.	Nodule.	At first enlarged and later became smaller with rest.	Nodule.

TABLE V. Contd.

11.	Cavity in collapsed consolidated area.	Collapse and consolidation cleared and the cavity blocked.	Blocked Cavity.
12.	Diffuse shadowing.	Cleared leaving nodular disease which cavitated and re-blocked.	Blocked Cavity.
13.	Cavity in diffuse shadowing.	Blocked under A.P. and enlarged after A.P. was abandoned.	Blocked Cavity.
14.	Smudge.	Enlarged to form nodule which cavitated.	Cavitating Nodule (which had re-blocked by the time it was excised.)
15.	Cavity in diffuse shadowing	Cleared under treatment leaving solid nodule.	Blocked Cavity.
16.	Diffuse shadowing	Cleared under treatment leaving solid focus	Nodule
17.	Cavity with some diffuse shadowing surrounding it.	Cavity blocked.	Blocked Cavity.
18.	Cavity with some exudative shadowing surrounding it.	Cavity blocked.	Blocked Cavity (though not completely solid.)

TABLE V Cont d.

19.	Thick-walled cavity	Blocked. Re-cavitated. Re-blocked.	Blocked Cavity.
20.	Nodule with diffuse shadowing surround-ing.	Cavitated then blocked.	Blocked Cavity.
21.	Diffuse shadowing.	Cleared with treatment, leaving nodule.	Nodule.
22.	Diffuse shadowing.	Cavity appeared within, then blocked.	Blocked Cavity.
23.	Nodule.	Enlarged and cavitated.	Cavitating Nodule.
24.	Nodule.	Suspicion of cavitation.	Cavitating Nodule.

PATHOLOGY.

All the resected specimens were fixed in 10% formol-saline before being examined. They were submitted to macroscopic and microscopic investigation. Then each in turn was studied in conjunction with the approximate radiographs and tomograms for the purpose of co-relating their various features.

The specimens of cases 1, 2 and 3 were poorly preserved and of little use for studying the pathology and the specimen of case 10 could not be traced. However, careful examination of the remaining twenty-one specimens allowed for a fairly comprehensive picture of the morbid anatomy.

The interval of several weeks before tomography of a nodule and its surgical removal again presented some difficulty when co-relation of radiological and morbid anatomy features was attempted, for it allowed time for a change to occur in the lesion. However, this possible pitfall was always borne in mind.

SIZE AND SHAPE.

Most nodules were similar in size and shape to the shadows in the pre-operative tomograms. As in the case of the radiological measurements, the smalle st nodule was about 1.5 cm. and the largest about 4 cm.

NAKED-EYE APPEARANCES.

The nodules were exposed by cutting them approximately through the largest diameter.

Typically they were of a fairly dense but variable consistency. In nineteen of the twenty-one specimens a degree of softening which was more marked towards the centre was noted. The central core could be disintegrated readily with a blunt probe and in some cases could be washed away with a jet of water, as occasionally did happen accidentally in the course of inspection, an artificial cavity resulting. The peripheral regions by contrast were not so friable. These observations were true both for encapsulated caseous foci which were undergoing softening and for thick-walled cavities which had blocked. In the case of thin-walled cavities which had blocked, the resulting nodules were composed throughout of soft material of uniform structure and friability. Good examples of this type were seen in cases 17 and 20.

In several cases where softening had progressed to liquefaction and communication with a bronchus established, some evacuation of the material was seen to have occurred, with the formation of a cavity within the lesion. The cavity usually occurred close to the junction of the bronchus and nodule as seen for example

in Figs. 6b, 7b and 12b. It was difficult to be sure which of these cavities were genuine and which resulted during inspection, but there was no doubt that cavitation was merely a more advanced stage of the process and a potential outcome if a liquefying lesion was allowed to continue untreated. It was obvious then that liquifaction within the nodule with formation of tuberculous pus, was the immediate forerunner of cavity formation and possible bronchogenic dissemination of the disease.

The area of softening was distinguished from the remainder of the nodule, not only by its consistency but also by its colour. Usually of a uniform yellow or yellowish-white shade, it was distinct from the outer parts which were greyer and contained carbon pigment in variable amounts deposited either as flecks (Figs. 9b and 22c) or arranged in concentric laminations (Figs. 4b, 7b and 24b). Pigmentation was seen mostly in parts of the nodule which had never been excavated and in which softening was not marked. It was practically never seen in the caseous material filling a blocked cavity (Figs. 17e and 20e).

CAPSULE.

All the nodules were encapsulated by fibrous tissue which formed a band of variable thickness.

Often the capsule appeared continuous with the walls of the related bronchus and some small nodules were actually pockets of caseous debris sealed in the bronchial lumen by proximal and distal stenoses. A good example of this is seen in Fig. 13c.

THE RELATED BRONCHUS.

Tuberculous disease was always present in the bronchus related to the caseous nodule, whether it was a blocked cavity or a caseous focus which had never cavitated. The effect of this bronchial tuberculosis was to produce a partial or complete occlusion of the bronchial lumen and it was apparent that the resultant alteration in the bronchial mechanics probably played a considerable part in the formation and behaviour of the focus. This is similar to the well-known effect of bronchial disease on the formation and behaviour of some tuberculous cavities (Pearson, 1930; Coryllos, 1933b; Price-Thomas, 1942).

In only one case (No. 22), in which the nodule was removed by wedge resection, was no related bronchus seen, either at operation or on examining the specimen.

Macroscopic evidence of tuberculous bronchitis in relation to the nodule was seen in sixteen cases. In half of these an ulcero-caseous process involving the inner layers of the bronchial walls was the outstanding

feature. The accumulation of caseous debris was responsible for narrowing and in some cases blocking the lumen. In the other half, a proliferative thickening of the bronchial walls was the major change, the end result of this process being organic stenoses. In several cases evidence of both types of tuberculous bronchitis was seen, although one or the other type was predominant in each case. Complete stenoses was difficult to prove macroscopically although narrowing of the lumen was fairly obvious and bronchi ending blindly in the vicinity of the nodule was a common finding.

ATELECTASIS.

Atelectasis was to be expected in the presence of such marked bronchial disease, so that the regular finding of it in association with caseous nodules was no surprise.

In five cases (Nos. 5 right and left, 14, 15 and 16) the atelectasis probably involved a whole segment though it was difficult to be certain of this. In six others (Nos. 4, 8, 12, 18, 19 and 20) it was fairly marked while in the remainder it was present but not gross. Since cases 21 and 22 were removed by wedge resection, on account of their sub-pleural situation, it was impossible to know the extent of the atelectasis

for only a small amount of surrounding lung tissue was removed with the nodule. Marked pleural dimpling was, however, present.

In case 24, no obvious collapsed lung was seen but a fibrous septum was seen to radiate from the focus and was thought to represent an area of old-standing atelectasis. Similar radiations were seen in the specimen of case 17, but some recent patchy collapse was also present.

MICROSCOPIC FINDINGS.

In sections stained with haematoxylin and eosin, two types of necrotic tissue were seen in the nodules:-

(1) Caseous pneumonitis (Fig. 27) in which the vague outlines of lung structure were still visible. In Fig. 27 the cellularity of the tissue is well shown and the hazy outlines of the former alveoli are recognisable. Two vessels are seen. As the process progressed, all tissue elements - alveoli, interstitum, bronchi, vessels and nerves - were involved in the destruction and reduced to -

(2) Amorphous caseous debris (Fig. 28) in which no tissue structure was at all recognisable and which stained uniformly pink. Fig. 28 shows a section of a nodule in which the

dividing line between the caseous pneumonitis and the amorphous debris is well shown.

Conservation of structure was generally found in the peripheral regions of the nodules and amorphous debris in the areas of softening nearer the centres. It seemed that the formation of the structurless debris was concurrent with softening of the lesion and represented a later stage in the destructive process than the caseous pneumonitis in which tissue remnants were still visible. In cases 14, 17 and 20, in which thin-walled cavities blocked, no areas of caseous pneumonitis were seen, the nodules consisting throughout of uniform, amorphous, caseous debris.

The presence of atelectasis was frequently confirmed by microscopy. Fig. 29 is an average example. It did not differ from atelectasis resulting by other pathological causes, but occasionally the presence of small nodules and tubercles was noted within it.

Microscopic sub-mucosal tubercles (Fig. 5), in bronchi in which the lining epithelium was normal and which showed no macroscopic evidence of tuberculosis, were often seen in the specimens. It was obvious that these tubercles had not arisen by direct implantation via the bronchial epithelium and it was inferred that they had gained access through the bronchial

sub-mucosal lymphatics. In Fig. 26 are seen tuberculous giant cells in interstitial lymphatics, which are related to a small vessel or bronchus, although the latter are not clearly seen in this specimen.

The naked eye and microscopic findings in this study emphasise the pathological similarity of blocked cavities and caseous nodules which had never cavitated. Each is a localised mass of more or less solid tuberculous tissue, the centre of which is known to be populated by numerous tubercle bacilli (Medlar, 1952, Macleod and Tait Smith, 1952). On its proximal side is a tuberculous bronchus, the occlusion of which prevents the lesion from spreading via the bronchial tree and on its distal side is an area of atelectasis - the consequence of the bronchial occlusion - in which the tuberculous infection may be kept smouldering.

DISCUSSION.

Two main types of caseous nodules were seen:-

(1) The blocked cavity.

(2) The non-cavitated focus of caseous pneumonitis.

Both these types were radiological entities and their development was traced in serial radiographs. The blocked cavity was diagnosed when a tuberculous cavity, present in earlier films was later seen to be replaced by a nodular opacity of similar size and shape. The non-cavitated focus was observed to gradually enlarge from a small "smudge" shadow.

In addition to these two modes of development, some nodules became visible when a rather widespread area of exudative shadowing cleared, following treatment by chemotherapy. The pathological process represented by this radiological sequence of events was not clear, but two of the cases in this group showed the histological picture of caseous pneumonitis and in two, there was evidence of cavity blocking. Furthermore, in case 15, a cavity was seen within an area of exudative shadowing in the diagnostic radiograph. The cavity blocked and the exudative disease cleared with treatment.

These findings suggested that nodules emerging from clearing areas of exudative shadowing might be either blocked cavities or non-cavitated foci, in which

the exudation was merely a small bronchogenic spread, occurring during development. At anyrate, it seemed unlikely that they constituted a third group of nodules with a different pathogenesis from the others.

The main purpose of the investigation was to co-relate the clinical, radiological and pathological findings in this series with a view to establishing criteria on which the two types of nodules - blocked cavities and non-cavitated foci - could be differentiated.

Symptoms and clinical signs were obviously of little assistance, for both were usually either slight or absent. When present, they were merely the signs and symptoms of early pulmonary tuberculosis. It was significant that thirteen (54%) of the present cases were symptomless and were "picked up" by mass or routine radiography. Wang (1953) was of the opinion that the use of mass radiography in recent years is responsible for the apparent increased incidence of the condition. In his survey of nineteen cases, four were found between 1939 - 1949, while fourteen (74%) were diagnosed by mass radiography in the past two and a half years.

The radiographic appearances offered more scope for obtaining data of differential diagnostic value.

There was no problem where serial radiographs, covering the developmental phase, were available. The lesions seen in Figs. 17d. and 22b. were blocked cavities, as proved by the previous radiographs, but, had they been first seen in the fully-formed state, they would have passed for nodules of either type. Similarly, the nodule illustrated in Fig. 14b. developed from a "smudge" shadow seen in an earlier film, but this would never have been known, had the nodule been fully developed when first diagnosed. Nine (36%) of the present cases presented as nodules on the initial radiograph and the difficulty of placing them in one or other group was considerable. Houghton (1950) expressed this same difficulty. Study & Morgenstern (1949) too, stated that serial radiography was the only method of differentiation.

Nevertheless, an attempt was made to co-relate the radiological with the pathological features in order to see if there were any special points on which a distinction could be made.

Firstly, the size, shape and multiplicity of the nodules were considered in relation to the radiological groups. The results are shown in Table VI.

Group A. - Development unknown.

Group B1. - Blocked cavities.

Group B2. - Development from "smudge".

Group B3. - Emergence from exudative disease.

TABLE VI - RELATIONSHIP OF SIZE, SHAPE AND MULTIPLICITY TO THE FOUR RADIOLOGICAL GROUPS. 24 CASES.

Radiological Group.	SIZE.				SHAPE.			MULTIPLICITY	
	1.5 cm. or less	1.6-2.5 cm.	2.6-3.5 cm.	3.5 cm.+	Round	Oval	Pleomorphic	Single	Two or More.
A.	2	4	1	2	4	2	3	4	5
B1.	1	4	2	0	1	4	2	6	1
B2.	0	4	1	0	2	2	1	2	3
B3.	1	3	0	0	3	1	0	4	0

It was obvious from these figures that nodules of all types might be present in any size, shape or multiplicity and therefore these factors were of no diagnostic help.

Secondly, it was considered whether the site of occurrence bore any relationship to the type of nodule. Twenty cases (80%) occurred in the apical and posterior segments of the upper lobes and those twenty included nodules of all types. Of the remaining five, one occurred in the anterior segment of the left upper lobe, two occurred in the apical and two in the lateral basal segments of the right lower lobe. Of these five, one belonged to Group A, two to Group B1 and two to Group B3. No evidence of value was thus obtained.

Thirdly, the presence of "tramlines" was compared with the finding of bronchial disease in the resected specimens. In fifteen cases, both were found, and of these, five belonged to Group A, four belonged to Group B1, four to B2 and two to B3. Six other cases showed bronchial disease in the specimen, although "tramlines" on the radiograph were either absent or their presence was doubtful and of these, two belonged to Group A, two to Group B1, one to Group B2 and one to Group B3. The presence of "tramlines" and bronchial disease, therefore, was not restricted to nodules of a

particular type.

Fourthly, the twelve cases showing both radiographic and pathological evidence of atelectasis associated with the nodule, were considered in relation to the radiological groups. Four cases belonged to Group A, four to Group B1, three to Group B2 and one to B3. Cases 1 and 3 also showed radiological evidence of atelectasis, but the specimens were unsuitable for examination and its presence could not be confirmed pathologically. Case 1 was in Group A and Case 3 in Group B1. Again no significant diagnostic information was obtained.

Finally, the question of radiographic translucency within the nodule and the presence of cavitation in the specimen was considered as a possible clue to differential diagnosis, but this factor was so unreliable as to be of little use. The degree of translucency varied widely and artificial cavity formation occurred during inspection in cases showing marked softening and liquifaction. In addition the state of some nodules had obviously changed in the interval between the taking of the last tomogram and the resection of the lesion. In other words, it was impossible to be certain that a certain radiological translucency did or did not represent actual cavitation. It was thought, however, that the softening, which appeared

to be a fore-runner of potential cavitation, might account for a degree of relative translucency. In twenty-one cases, a radiographic translucency was seen at some time, and in seventeen of these the translucency was present at or shortly before the time of operation. Of those seventeen cases, seven belonged to Group A, five to Group B1, four to Group B2 and one to B3. One of the Group A cases and one of the Group B2 cases went through the blocked cavity phase before being resected. Only eight of these cases showed cavitation in the specimen and of these four belonged to Group A, three to Group B2 and one to Group B1. From all these findings then, it was clear that in the absence of serial films, distinction of radiological grounds was extremely difficult if not impossible.

It is not proposed to consider in detail, the differential diagnosis from other lesions casting radiological round shadows. Primary and secondary carcinoma, lung abcess, encapsulated effusion or empyema, cysts and simple tumours like adenoma, lipoma, fibroma and hamartoma may all cause difficulty. It is possible, however, that the presence of "tramlines" may be of use in differentiating the tuberculous from the non-tuberculous condition. There are always a few cases in which no definite diagnosis can be reached even

at operation and histological examination is necessary before the true nature of the lesion is known.

The similar radiographic appearances of caseous nodules and their common behaviour trends were not surprising in view of the similar morbid anatomical features which were found on examining the specimens. In many specimens it was not possible to say on pathological grounds alone, to what type the nodule belonged. In a few specimens such as these illustrated in Figs. 17e and 20e, in which a completely uniform soft mass of caseous debris was contained within a fairly thin capsule, it was possible to say that the lesions were probably blocked cavities. Similarly, if a nodule had been seen which consisted throughout of caseous pneumonitis without softening it was fair to say that it was a focus which had never cavitated. No such nodule was seen in the series. In all nodules, some softening with loss of tissue structure had occurred and it was impossible on pathological grounds to be sure if these nodules were caseous foci undergoing liquifaction or if they had actually formed thick-walled cavities which had blocked and refilled with caseous material. The difficulty in distinguishing them arose because, histological evidence of lung structure was visible in the periphery of nodules of both types. Auerbach and Green

(1942) commented on the problem of distinguishing an inspissated cavity from (1) an encapsulated caseous focus which had never cavitated and from (2) a similar focus undergoing liquifaction. In the first instance (1) they submitted that there are two points which may be helpful: "(a) The centre of the caseous focus is firmly attached to its wall and unlike the inspissated cavity it cannot be washed out with a jet of cold water and (b) microscopic examination of the caseous focus with elastic stain shows elastic fibres outlining the former lung parenchyma, while in the inspissated cavity only disorganised remnants are usually seen. The second differential (2) is extremely difficult and may be impossible.

The present findings agree largely with these opinions, although foci without softening were not seen in any of the specimens and would probably be seen only in specimens resected much earlier in the course of the disease.

The finding of occluded tuberculous bronchi in relation to the caseous nodules was common and atelectasis caused by the bronchial occlusion was invariably seen. Atelectasis has not hitherto been regarded as a component of this type of disease (Moyes 1951 and Pugh, Jones and Martin 1952). The extent of the collapse was proportionate to the size of bronchus

occluded. It was often only slight but in five cases it probably involved a complete segment. In case 20, segmental collapse was suggested by the bronchogram (Fig. 20d.) but in the specimen it was not extensive. Probably some re-aeration occurred before operation. Case 5 (right) was interesting in that radiologically, the nodule occurred near the apex of a wedge-shaped area of segmental atelectasis, a point which has also been described by Kerley (1951). In case 16, the nodule probably occurred in a similar site, though the radiological evidence was not so convincing.

As is the case with atelectasis, no great attention has been focused on associated bronchial disease as a feature of the morbid anatomy of caseous nodules in general, although its importance in the formation of blocked cavities has been stressed by Auerbach & Green (1942), Pagel & Simmonds (1942) and by Loesch (1944).

Some evidence of bronchial tuberculosis was seen in every specimen examined in the present study. Even in bronchi in which no disease was visible macroscopically, sub-epithelial tubercles and giant cells (Figs. 25 and 26) were seen in the microscopic section. Clegg (1953) stated that he has never failed to demonstrate sub-epithelial tubercles in resected tuberculous lung specimens, even in those in which no pneumonic focus

of any consequence was present. The occurrence of such tubercles in sites over which the bronchial epithelium is normal (Fig. 25) is not consistent with the theory that tuberculous bronchitis arises by direct implantation, from infected sputum passing along the lumen. Furthermore, sputum is rarely obtained from cases of nodular disease and when it is, it is seldom heavily positive. These facts suggest that tuberculosis spreads by the lymphatics of the bronchial wall, as was taught by Muir (1941). Coryllos (1933a) wrote: "It is well known that pulmonary tuberculosis, more than any other disease in the lung, is accompanied by early and marked bronchial changes." Coryllos was concerned with the effect of the state of the bronchi on the formation and behaviour of distension cavities but bronchial occlusion or patency is equally important in the subsequent behaviour of caseous nodules. Whatever other factors play a part in the limitation or spread of a tuberculous lesion, such as number, strain and virulence of the bacilli and age, sex and resistance or hypersensitivity of the host, a mechanical factor - bronchial occlusion or patency - is of considerable importance.

While tuberculous bronchitis and bronchial occlusion in relation to blocked cavities have been described, little mention has been made of their presence

in relation to non-cavitated caseous nodules. Pagel & Simmonds (1942) however, mentioned that in addition to blocked cavities, Assman's and other round foci also exhibit caseous bronchitis and in some of them the caseous bronchitis forms the main part of the changes or the lesion itself. Of the fifteen cases which showed both "tramlines" radiologically and bronchial disease in the specimen, eight were of the non-cavitated nodule type (admittedly showing early cavitation) and seven were blocked cavities. Pagel & Simmonds (1942) thus, first drew attention to the importance of tuberculous bronchitis in the development of caseous nodules and pointed out that the lesions might be exclusively bronchial in origin. The small lesion in Fig. 13c. was actually a pocket of tuberculous pus contained in a bronchial dilatation but larger lesions of this type, such as that reported by Brock (1946), were not seen. Clegg (1953) described the formation of a bronchial cold abcess, a lesion which is characterised by the absence of pneumonic disease and which conceivably falls into the category of caseous nodule. A bronchial cold abcess is formed by the coalescence of adjacent, caseous and occluded bronchi, which are drawn together by atelectasis resulting from the occlusion of the bronchi. It seems likely that the absence of alveolar involvement signifies that such an

abcess is an early state in the development of a caseous nodule, for caseation must sooner or later involve and destroy, not only the surrounding alveoli, but all tissue elements with which it comes in contact. The assumption is therefore that nodules developing in this way become eventually foci of caseous pneumonitis with all the problems of diagnosis, prognosis and treatment that apply to caseous nodules in general.

Graham & Singer (1936), Haight & Farris (1939) and Macleod & Tait Smith (1952) described a type of caseous nodule in which concentric lamination was the outstanding morbid anatomical feature. The laminations consisted of tuberculous granulation tissue and pigmented fibrous tissue alternately and Macleod & Tait Smith suggested that the layers represented successive phases of activity and relative quiescence in the life of the lesion as it gradually increased in size from within outwards. These writers thought that pigmentation of the fibrous layers was a secondary phenomenon, but it is more likely that the carbon pigment was already present in lung tissue before it was involved in the disease process. In the present specimens it was seen not only in lamellar form, but also in scattered flecks throughout the nodule. Carbon pigment was present mostly in areas where structure was conserved and rarely in soft amorphous caseous areas.

While some laminated foci cavitate and are a source of danger, others may eventually heal and calcify as did the lesions described by Graham & Singer (1936) and Haight & Farris (1939). No outstanding example of a laminated focus was seen amongst the present specimens but in cases 4, 7 and 24 there was some suggestion of lamination.

When multiple nodules occur, there is usually a large or predominant lesion and one or more smaller ones. To the smaller ones Moyes (1951) gave the name "satellite foci", and stated that the presence of such satellites favoured a diagnosis of tuberculosis when there was uncertainty regarding the nature of the major lesion. He did not offer any explanation of their origin. One possibility is that they develop in the same way as the parent nodule, either as a bronchogenic spread from it or from a fresh exogenous infection. However, in the light of what has been said regarding the extension of the tuberculous process via the bronchial lymphatics, there is no doubt that some, at least, of these satellites occur by lymphatic permeation. As confirmatory evidence, the finding of branched "tramlines" to two separate nodules is a fairly common occurence.

The question of whether some caseous nodules are primary foci is often disputed. With one possible

exception, in which a mass of hilar glands was found at operation (Case 10), but in which the pre-operative radiographs did not suggest this, no case in this series stood out as a primary focus. Nassau & Pagel (1951) held that the primary complex, occurring in the adult, does not usually have a marked glandular component. They stated too, that in their experience, adult pulmonary tuberculosis often springs direct from the primary infection. These views are not generally accepted, but if they are true, then it is likely that a proportion of the lesions in this series were primary.

The fact, however, that the caseous nodules were present mostly in the posterior regions of the upper lobes of the lung, which are the parts most commonly affected by adult pulmonary tuberculosis, did not favour their being primary foci. Helm (1951) and Moyes (1951) both pointed out that the posterior segments of the lungs, especially those of the upper lobes, are the sites into which infected material is likely to be aspirated in the recumbent position. It would seem, therefore, that the majority of caseous nodules have a bronchogenic origin and that the non-cavitated type, at anyrate, are probably early manifestations of adult pulmonary tuberculosis.

An attempt was made to obtain information which would throw some light on the prognosis of each type of nodule

for it was obvious that unless the prognosis was materially different in each case then the necessity for accurate diagnosis was not so important.

There are several courses which caseous nodules may take. They may become smaller and heal by fibrosis and calcification. This is the ideal outcome and obviously nodules progressing along these lines should be left untreated and merely observed. Calcification in itself, however, is no reliable guide as to the activity of the lesion. Five of the present specimens showed co-existing calcification and cavitation, Case 4 being a good example in which both were marked.

Secondly, they may remain stationary for many years. This was not seen in these cases, because of the relatively short period of surveillance. Even after a long period of quiescence they may become active again.

Thirdly, they may enlarge gradually. This is well illustrated in Figs. 23a, b and c. Enlargement is a danger sign, heralding the imminent occurrence of the fourth possibility, cavitation. Cavitation is much to be feared for it may be accompanied by bronchogenic spread (Figs. 4d. and 14d.).

The prognosis of caseous nodules has long been a subject of much controversy and various writers have announced widely divergent views. Bruck (1934) regarded

them, for the most part, as dormant on account of their fibrous capsule. Birkelo & Kasper (1937) thought they represented a "benign" form of tuberculosis. Bobrowitz (1943) was of the opinion that caseous nodules were merely a stage in cavity healing and Shamaskin (1941) and Study & Morgenstern (1949) thought the prognosis of inspissated cavities was good. Others have emphasised the potential instability of caseous nodules and have advised treatment by resection on this account. (Thornton & Adams, 1942; Sellors & Hickey, 1949; and Mahon & Forsee, 1950). Oleneva (1946), in a study of fifty cases, observed that a considerable number showed cavitation and extensive spread. He thought the prognosis was rather serious. Houghton (1950) regarded them as "time-bombs", which could explode without warning into widespread tuberculosis. Of the recent writers, only Eriksen (1949) and Moyes (1951) took an optimistic view regarding the prognosis and even they admitted the eventual need for resection in a few cases. Shields et al (1952) attempted to give an indication of the prognosis of various radiological types of nodular tuberculosis, but they admitted that it is dangerous to make generalisations and while their figures gave a rough idea of the prognosis of each type, they emphasised the need for careful and prolonged observation in each individual case. O'Brien

et al (1953) stated simply that there is no known method of evaluating the relative danger of these lesions, and thus, further strengthened the case for careful individual observation.

In all the present cases, the nodule was regarded at the time of operation as a dangerous lesion if left untreated and resection was thought to be the most logical and effective means of dealing with it, even though the operation carried a greater risk than other therapeutic procedures.

Information of any value, bearing on the prognosis, is obtainable only from a study of a large series of cases, treated conservatively and followed for a period of several years. Only a few impressions were obtainable from the present small group of cases, in which the natural history was artificially terminated by surgical removal of the nodules. In any case, the prognosis in all these cases was regarded as poor at the time of the operation. Otherwise, such radical measures would not have been employed in their treatment.

The appearance of a radiological translucency within the nodule was seen to be a danger sign. In twelve of the seventeen cases in which it was present at or shortly before operation, acid-fast bacilli were

were isolated within the two preceding months and in seven of these cases, the blood sedimentation rate was rising slightly over the same period. Seven of these cases were blocked cavities and five were nodules which were apparently beginning to cavitate. In only eight of the seventeen cases showing translucency was cavitation seen in the specimen, but, in view of the rapid morbid anatomical changes which took place in the nodules between the taking of the tomograms and the resection, this was not surprising.

In two cases showing translucency, but in which no other evidence of activity was found, cavitation was present pathologically. This confirmed the dangerous significance of translucency in the nodule.

In eight cases there was no translucency at, or about the time of operation. Of these, tubercle bacilli were isolated in the two preceding months in only one case, and in one other, the blood sedimentation rate showed a slight upward trend. Absence of translucency, therefore, was generally associated with absence of other evidence of activity. Six of these eight cases were blocked cavities in which the blocking of the cavity resulted in at least temporary quiescence. The other two cases were those non-cavitating foci which never

showed a translucency at any time during the observation period (cases 10 and 21.). Despite the fact that radiological translucency was absent in these eight cases, pathologically, cavitation was seen in four, although two of these may have been aritifical cavities formed during examination.

It was seen, therefore, that both blocked cavities and non-cavitated foci of caseous pneumonitis break down, form cavities and lead to dissemination of the disease. The development of a radiological translucency is of bad prognostic significance and is often associated with positive tests for acid-fast bacilli and with elevation of the B.S.R. No reliance can be placed on the type of the nodule in assessing its prognosis and careful radiological observation of each nodule is required in order that treatment may be instituted when the lesion shows evidence of activity. Though all caseous nodules may not be sources of danger, all are potentially so. Continued watching is, at the moment, the only safeguard.

For the stable and unchanging lesion or for the lesion which is retrogressing there is no case for active treatment. If these cases are left under the eye of the physician, so that treatment can be instituted if and when necessary, then that is sufficient.

For the cavitating lesion which requires treatment there is much debate and controversy as to the form it should take. Bed-rest has always been regarded as the first fundamental step in the treatment of any active tuberculous condition and, therefore, it has a place in the early treatment of caseous nodules. It is obviously not sufficient in itself. Bed-rest in conjunction with prolonged chemotherapy may have greater effect, but no reports on this are yet available. Most of the present cases had short courses (one to four months) of streptomycin with para-amino-salicylic acid or izoniazid, and some slight diminution in size of the nodule was observed in a few cases. Chemotherapy for such short periods, although rapidly effective in clearing associated exudative shadows, is scarcely adequate for solid and encapsulated nodules and it is possible that were it given for perhaps a year, a greater effect might be obtained. Mahon & Forsee (1950), however, were of the opinion that streptomycin had little effect on caseous nodules and indeed that all forms of medical treatment were relatively ineffective. Shields et al (1952) thought that bed-rest was of little avail and that chemotherapy hastened the clearing only of the exudative or reversible element. They further thought that collapse therapy of any sort

would not lessen the chances of reactivation.

Assman (1930) suggested artificial pneumothorax and some of Moyes' (1951) cases did well with this form of therapy. The lesion is not obliterated by the pneumothorax, however, and still appears as a nodular shadow in the collapsed lung. Even in a nodule with central cavitation, reversion to a completely solid mass is all that can be expected; how satisfactory this outcome of pneumothorax treatment is, is open to question for there is a possibility of breakdown after the pneumothorax is abandoned. Pinner(1942) stated that when a caseous bacilliferous mass still remains, anatomical healing cannot be regarded as complete, even though such a situation may be a step towards healing.

Eloesser (1937) and Shamaskin (1941) thought that blocked cavities did not respond well to collapse therapy although if there was a tendency to recurrent excavation, collapse therapy might close the bronchus and maintain the nodule in the solid state.

In recent years, treatment by lung resection has been generally preferred, though in some circles it is being used indiscriminately, and caseous nodules of all descriptions are being resected even though they appear to be stable and unchanging lesions. The advice of

Sellors & Hickey (1949) and Mahon & Forsee (1950) in urging excision of all caseous nodules on account of potential instability and diagnostic difficulties, is largely responsible for the widespread and often unwarranted use of resection. The present position is, that there is so much uncertainty with regard to which nodules should be resected and which should not, that O'Brien et al (1953) have described the situation as "chaotic". The results of 729 resection operations performed by Bickford et al (1952) are no doubt encouraging, but their mortality rate is 1.92% and morbidity rate nearly twice this figure. In the present series there were no deaths, but two cases have persistent broncho-pleural fistulae with empyemas and in one case there has been reactivation of residual disease.

Of the operative procedures, resection would seem to be the only effective one, but it is obvious that it is not to be advised in every case, least of all in cases where more conservative measures would give equally good results. When it does appear that resection is indicated, wedge or segmental resection is particularly desirable, for the diseased area can be removed with minimum loss of functioning pulmonary tissue.

A general plan of treatment, therefore, is suggested. Each case must be considered individually and constant

and prolonged observation is of prime importance in sound management. When signs of activity appear, bed-rest and chemotherapy for a minimum of six months are indicated and may, in themselves, achieve such improvement in the condition that further observation may be all that is required. For those nodules, which do not improve with this treatment or which show a tendency to recurrent break-down, resection is at the moment, the most logical and effective treatment available, but its mortality and complication risks must always be borne in mind.

CONCLUSIONS.

The following are the main conclusions drawn from the study:-

(1) There are two main types of caseous nodules, both of which are of fairly equal occurrence:

a) The blocked cavity.

b) The non-cavitated focus of caseous pneumonitis.

The former may occur at any phase of pulmonary tuberculosis but the latter is probably a fairly early stage in the evolution of the disease.

(2) The two types cannot be differentiated clinically, because symptoms and signs are slight or absent. Routine or mass radiography is responsible for discovering many cases of this type of disease, and probably accounts for the apparent increased incidence in recent years.

(3) Radiologically, the nodules cannot be distinguished from one another when they are fully formed although differentiation is possible when serial films covering the developmental phase are available. "Tramlines" which are the radiological representation of bronchial disease, are a prominent feature of both types, and, although of no help in differentiating the types of tuberculous nodules, may be of value in distinguishing the tuberculous from the non-tuberculous round shadow.

(4) Pathologically it is not always possible to distinguish one type of caseous nodule from another. Each is a localised, encapsulated mass of tuberculous tissue, with a tuberculous bronchus on its proximal side and associated atelectasis distally. The bronchial disease leads to bronchial occlusion - complete, partial or intermittent, and this is largely responsible for the subsequent behaviour of the focus. In the peripheral regions of nodules of both types, necrotic tissue, in which there is some conservation of alveolar outlines, can usually be seen and this makes differentiation, even on microscopic grounds, very difficult.

(5) Not only do the majority of caseous nodules resemble each other in clinical, radiological and pathological aspects, but they are capable of behaving in similar fashions. They do not all have an unfavourable outcome, though each nodule must be regarded as a potential source of danger. Unfortunately, the relative prognosis of each type is not yet known and is only likely to be ascertained by large statistical studies.

(6) The probable prognosis in each individual case is therefore difficult to assess, and continued observation is the only reasonable precaution one can take. Signs of activity, such as radiological translucency within the lesion, a positive sputum or a rising B.S.R. are the

indications that treatment is required.

(7) The actual treatment employed is the subject of much controversy but no treatment is indicated for the stable and unchanging nodule. Bed-rest has a place in the early treatment and it is possible that, in conjunction with longer courses of chemotherapy than are generally employed, satisfactory results may be obtained. No controlled studies of treatment by prolonged chemotherapy have yet been reported. For refractory cases requiring operative surgical treatment, segmental or wedge resection appears to be the logical and most effective procedure but the operation may have serious consequences which must be borne in mind, whenever it is considered.

SUMMARY.

Observations on the clinical, radiological and pathological features of caseous nodules of the lung are presented, as seen in twenty-five cases treated by resection.

Historical facts on the condition are listed and the literature is reviewed.

The difficulties in distinguishing the types of caseous nodules from each other and from other conditions casting round pulmonary shadows, are pointed out. It is suggested that as the two main types of caseous nodules bear great resemblance to each other in structure and potential behaviour, there is no real necessity that they should be differentiated, for they require a common plan of treatment.

Careful observation is the foremost necessity and treatment is indicated only when signs of activity appear. The possible forms of treatment are discussed and the eventual need for resection in the unstable cases is mentioned.

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APPENDIX.

CASE HISTORIES.

CASE 1. D.C., a soldier, aged 21, volunteered for mass miniature radiography examination in March 1951 because his sister had died two years previously of pulmonary tuberculosis. He was symptomless at the time but was, nevertheless, reported as having an oval area of infiltration in the left upper zone and sputum examined at the time was positive for acid-fast bacilli on direct examination (the only positive result ever obtained in his case). He was treated by streptomycin (90 G.) with para-amino-salicylic acid (P.A.S.) but despite this the oval shaped lesion was thought to show radiological evidence of cavitation within it and he was transferred to a chest hospital in December 1951. On admission he was still symptomless, but physical examination revealed some fine crepitations in the left infraclavicular area. His blood sedimentation rate (B.S.R.) was consistently normal at about 5 mm. in one hour.

His radiograph (Fig. 1a.) showed an isolated round shadow in the left upper zone at the anterior end of the first rib. The outline was fairly well defined and there was a well marked area of translucency within it, lying slightly eccentrically. There were also two parallel lines extending from the round shadow to the hilum and a linear streak in the first interspace. In

the right lung field there were two ill defined opacities at the anterior ends of the third and fourth ribs and a small round shadow in the first interspace.

In the tomogram (Fig. 1b.) the lesion in the left upper zone was rather irregular in shape, the translucency was more marked and some calcification could be seen within it. The "tramlines" to the hilum were not seen in this cut, but the linear shadow in the first interspace was well shown.

The tomograms of the right side revealed the two "fluffy" shadows in the ordinary film as two partly calcified round foci. The third round shadow in the first interspace was not defined in these tomographic cuts. All the shadows on the right side were thought to be relatively stable and to have undergone no change since the diagnostic film nine months before.

In February 1952, a left thoracotomy was performed: a solid mass, supplied by the whole segmental bronchus, was localised to the posterior segment of the left upper lobe and this segment was removed.

By the time the specimen came to be examined it had been considerably macerated and distorted and did not warrant photographing.

The lesion was found to be too calcareous for sectioning.

Comment. Multiple caseous nodules found on mass radiography: the largest was thought to show some radiological evidence of cavitation, but pathologically it was found to be grossly calcified and no cavity was present.

CASE 2. M.G., a schoolmistress, aged 30, with no family or contact history of tuberculosis, submitted herself for mass radiography examination in October 1951 and was found to have a round area of infiltration in the right upper zone.

After a period of chest clinic observation, she was admitted to a chest hospital in February 1952. She was, and had always been, completely symptom free; there were no abnormal physical signs in her chest; the B.S.R. was consistently normal and the sputum was never at any time positive for acid-fast bacilli.

Her radiograph showed little change from the diagnostic film. There was a uniformly dense round opacity in the first right interspace with a similar opacity behind the right second rib.

Tomographically (Fig. 2a.) the larger opacity was clearly defined in the 4 cm. cut and the smaller one appeared to have some exudative shadowing surrounding it. There was a slight suspicion of the presence of "tramlines", and of cavitation near the inferior margin.

Despite the absence of a positive sputum and the doubtful radiological evidence of cavitation, a segmental resection was performed on 30th May, 1952. At thoracotomy the disease was found to be in the posterior segment of the right upper lobe with two

pea-sized nodules nearer the hilum, the remainder of the lung being normal.

This specimen, too, was considerably macerated and distorted by the time it came to be examined, but the pathologist's report is helpful:-

"The cut surface shows multiple caseous foci the largest of which has excavated. Histologically the periphery of each lesion shows many giant cell systems and a bronchus in relation to the largest one is caseous."

Comment. A caseous nodule, found on mass radiography, which showed no clinical evidence of activity and only doubtful evidence of cavitation radiologically; but the specimen showed it to be partially excavated.

CASE 3. A.E., a female factory worker aged 19, was admitted to a chest hospital in April, 1951, feeling well but having had a slight productive cough for about six weeks. She had been diagnosed by mass radiography as suffering from pulmonary tuberculosis some four weeks previously and her sputum was positive at this time.

On examination there was increased dullness at the left apex posteriorly and a few rhonchi were heard in that area. Her B.S.R. was constantly normal, about 5 mm. in the first hour, and her sputum positive for acid-fast bacilli on direct smear.

Her radiograph revealed scattered infiltration in the left upper zone with a definite cavity behind the first rib. Following a period of bed rest for one month and a course of streptomycin (30 G.) with P.A.S. the cavity became smaller and appeared to be within a solid lesion. A satisfactory left artificial pneumothorax was induced in May, 1951, and maintained until January, 1952, at which time the cavity had become much larger (Fig. 3a.): the pneumothorax was, therefore, abandoned. By April 1952, the left lung had completely re-expanded and tomography (Fig. 3b.) revealed the lesion to be an irregular nodule with a suspicious translucency within it. In this tomogram too, "tramlines" and linear atelectasis peripheral to

the lesion could be seen.

Bronchoscopy revealed no abnormality and thoracotomy was performed on 6th June, 1952. The posterior segment of the left upper lobe was found to be atelectatic and diseased. It was resected.

Like the first two specimens, this segment was not of much value in elucidating the pathology, but the report was as follows:-

"The segment contains many areas of caseous tuberculosis with slight fibrous encapsulation. In microscopic section there are also large numbers of small cellular tubercles."

Comment. A tuberculous cavity which did not respond to treatment by artificial pneumothorax and which "blocked" after the pneumothorax was abandoned; it was found, in the specimen, to consist of a mass of caseous matter.

CASE 4. J.C., a young woman of 29, volunteered for mass miniature radiography in April 1948. Although she was free of symptoms at the time, nodular tuberculosis in the left upper zone was discovered and she was kept under observation. In September 1950, she felt a little tired and developed a slight productive cough, but there was no radiological change, although a positive sputum was produced. A second positive result was obtained in October 1951 and she was admitted to a chest hospital the following December.

On admission she still had an occasional productive cough and physical examination revealed some impairment of the percussion note in the left infraclavicular region. The B.S.R. was 2 mm. in the first hour and several specimens of sputum gave positive results.

Her radiograph on admission was not materially different from the diagnostic mass radiography film of April 1948. It showed a dense, partly calcified, irregularly oval shadow internal to the anterior end of the left first rib (Fig. 4c.) A smaller round shadow was present behind the second rib. In the 7 cm. tomogram the calcification appeared accentuated and in addition a very translucent semi-circular area surrounding the inferior margin of the large oval shadow was revealed.

One month after admission, the patient's temperature became elevated and the B.S.R. rose to 13 mm. in the first hour. These signs were associated with widespread exudative shadows in the left lower zone (Fig. 4d.) which cleared following a course of streptomycin (30 G.) with P.A.S.

It was then decided that this patient should be treated by resection, but the operation had to be postponed on account of a second bronchogenic "spread" similar to the one just described.

Bronchoscopy, which was done on 7th March 1952, revealed no abnormality.

Thoracotomy was carried out on 22nd August 1952 and the posterior and apical segments of the left upper lobe were resected.

The specimen, which is illustrated in Fig. 4b., showed a nodule contained within a fibrous capsule. The nodule contained a cavity in one part and in another there was extensive calcification. The bronchus was removed for sectioning and showed giant-cell systems at the point of surgical division.

Comment. A caseous nodule, found on mass radiography, which gave rise to two bronchogenic spreads before being resected; the specimen revealed cavitation and calcification present at the same time.

CASE 5. M.A., was a woman of 28. In 1943, at the age of 19, she became pregnant; she felt run down at the time and for this reason a chest radiograph was taken. This revealed minimal shadows in both upper zones. After a period of rest she had no further trouble, but in January 1946, while in hospital having another pregnancy terminated on account of hyperemesis, she had a routine chest film in which a new "smudge" shadow was noted in the second left interspace. She was kept under observation and in June 1947 two new "smudge" shadows were noted, one behind the left first rib and one behind the right first rib. She failed to attend the chest clinic again until January 1949, and by that time the shadows in both upper zones were more marked. By January 1951, the lesions were fairly well outlined and appeared to be of a tuberculomatous type.

In February 1952 it was suspected that there was a cavity within the lesion under the left first rib and a laryngeal swab culture was also positive at that time. She had a period of bed-rest at home before being admitted to a chest hospital in September 1952. On admission she was practically symptomless, there were no abnormal findings in the chest, and her B.S.R. was 2 mm. in one hour.

Tomograms revealed three round shadows in the left upper zone, the largest one with a definite central translucency, and on the right side, a wedge-shaped area of segmental atelectasis was seen (Fig. 5a).

Bronchoscopy revealed no abnormality. On 28th November 1952, the apical and posterior segments of the left upper lobe were resected. In the specimen three nodules were seen. The largest was partially excavated and the smallest showed some calcification. The associated bronchi were tuberculous.

Tomograms of the right upper zone were repeated in April 1953 and showed that much of the wedge-shaped shadow seen in the earlier tomograms had cleared, leaving a nodular shadow with a clear central area which suggested cavitation (Fig. 5c).

Resection of the apical and posterior segments of the right upper lobe was carried out on 21st May 1953.

In this specimen the large caseous focus was partially calcified and the related bronchus was tuberculous.

Comment. Bilateral multiple caseous nodules, all of which developed from "smudges" and which were treated by bilateral segmental resection; radiological suggestion of cavitation was confirmed in the specimens and the bronchi in relation to the foci were tuberculous.

CASE 6. E.C., a Jamaican nurse aged 28, came to England in February 1951, to continue her career. A routine radiograph then showed some "soft, fluffy" shadows behind and above the right clavicle. She continued to work until some 18 months later when she began to feel tired. A further radiograph showed that the shadowing in the right upper zone was more definite and was suggestive of nodular disease. In addition there was a new round shadow in the second right intercostal space.

On her admission to hospital on 12th September 1952, she was feeling well and symptomless. Her B.S.R. was 5mm. in one hour and there were no abnormal physical signs in the chest but one gastric lavage culture was positive for acid-fast bacilli.

Tomography revealed three nodular lesions in the right upper zone. The largest was shown clearly in the 6cm. cut (Fig. 6a) and there was an area of translucency within it. Above and medial to it was a hazy shadow which was actually another nodular lesion as defined in the 8cm. cut, while below and lateral was another ill-defined shadow which was another nodule as shown in the 5cm. cut. This cut also demonstrated well the parallel "tramlines". Bronchoscopy revealed no abnormality except for a trickle of mucopus from the right upper lobe orifice and this was negative for acid-fast bacilli on smear and culture.

In view of the solid nature of the disease and the suggestion of cavitation within the largest nodule, the apical and posterior segments of the right upper lobe were resected on 5th December 1952.

The specimen (Fig. 6b) showed two large caseous foci and two smaller ones, showing some calcification. The bronchi were tuberculous although normal at the point of surgical section. One adjacent subsegmental bronchus was dilated and filled with simple purulent exudate, thus suggesting a central bronchial stenosis.

Comment. Multiple caseous nodules seen to develop from "smudge" shadows; the pre-operative tomograms showed evidence of cavitation in the largest nodule and this was confirmed in the specimen. The related bronchi were tuberculous.

CASE 7. P.C., an Irishman of 34, with no relevant past or family history, presented himself for mass radiography in March 1951. This was normal.

However, in February 1952, following several months of vague ill-health, he developed pain in the right shoulder and also noticed some loss of weight, fatigue and an occasional cough.

A radiograph taken about this time revealed an area of nodular disease with a possible cavity and the sputum was found to be positive for acid-fast bacilli. Some improvement was obtained by streptomycin (30 G.) with P.A.S., but in August 1952 tomography revealed an area of solid disease still to be present and he was transferred to a chest hospital for surgical assessment. On admission he was symptomless, his sputum was negative, his B.S.R. was 6mm. in the first hour and there were no abnormal signs in his chest.

Tomograms (Fig. 7a) showed no change from those taken in August and on 26th December 1952, resection of the apical and posterior segments of the right upper lobe was carried out. The specimen (Fig. 7b) showed a partly laminated focus which was heavily pigmented. The walls of the related bronchus were thickened and its lumen narrowed. There was some slight excavation which may have been caused during inspection.

Comment. A caseous nodule which was fully formed and

probably cavitated when first diagnosed; the cavity blocked and the nodule was resected. The specimen showed early (and probably artificial) cavitation and the related bronchus was tuberculous.

CASE 8. E.B., a robust young girl of 18, was x-rayed in March 1950 at the request of her mother, who herself suffered from pulmonary tuberculosis. A "smudge" shadow in the left upper zone was noted and she was treated by bed rest at home for 15 months, after which she remained well until February 1952, when there was marked extension of the disease in the left upper zone and a cavity was seen therein. She was treated by streptomycin (50 G.) with P.A.S. before being admitted to a chest hospital in October 1952.

On examination there was some increased dullness at the left apex, but she was well, sputum negative and had a consistently normal B.S.R. Three months after admission however, she produced a positive laryngeal swab culture.

Bronchoscopy was done and no abnormality was found. Tomography revealed a rather irregular solid shadow in which no evidence of cavitation was seen (Fig. 8a.).

Resection of the apical and posterior segments of the left upper lobe was carried out in January 1953. The nodule (Fig. 8b) was markedly cavitated and the associated bronchus was thickened and occluded.

Comment. A case in which a cavity was seen to develop from a "smudge" shadow. Immediately before operation the cavity appeared to have blocked but the specimen showed definite cavitation. The related bronchi were tuberculous.

CASE 9. J.F., a man aged 33, decided to re-enlist in the Army in February 1952 but was rejected because a routine radiograph revealed nodular tuberculous disease in the right upper zone. There was no contact history of tuberculosis, his sputum was negative and he was completely free of symptoms.

He was treated for five months by streptomycin (48 G.) with P.A.S. and by a pneumoperitoneum with a right phrenic crush, but, although some clearing of the surrounding "soft" shadows occurred, the nodular lesion still persisted and was thought to be cavitating.

On admission to hospital in October 1952, he was still symptomless, sputum negative (a positive result was never obtained in his case) and had a B.S.R. of 3mm. in the first hour. Fine crepitations were audible at the right apex posteriorly.

Tomography (Fig. 9a) revealed a large homogeneous irregular shadow with a well marked area of translucency near its distal border. Bronchoscopy was normal and thoracotomy was carried out on 16th January 1953, when the apical and posterior segments of the right upper lobe were resected.

The specimen (Fig. 9b) showed a caseous focus surrounded by collapsed, fibrosing lung. The focus was heavily pigmented and of a mottled appearance. The caseous

area was slightly calcified. There were small satellite tubercles related to tuberculous bronchioles and one large and several small emphysematous bullae were seen.

Comment. A caseous nodule, found on routine radiography, which was fully developed when first seen and which showed no significant change while under observation; a well-marked radiological translucency, thought to be cavitation, proved to be an emphysematous bulla, when the specimen was examined.

CASE 10. P.G., a young girl, aged 18 and of rather low mentality, was admitted to hospital in October 1952. The previous May she had taken part in a mass radiography examination at work and had been found to have a round shadow about 1.5 cm. diameter under the second left rib. Three months later the shadow was slightly larger and treatment was advised.

On admission she was, and always had been, symptomless and no abnormal physical signs were found. A positive sputum was at no time obtained and her B.S.R. was consistently normal. Apart from some enlargement of the round shadow her radiograph (Fig. 10a.) showed little change from the first film taken in May 1952.

Bronchoscopy revealed no abnormality and at thoracotomy on January 23rd 1953, a solid lesion in the posterior segment of the left upper lobe was found associated with a large number of tuberculous hilar glands. The posterior segment was removed but unfortunately the specimen was lost. The pathologist reported two large caseous foci showing some central calcification and some smaller ones. The periphery of the large foci showed histologically the outlines of necrotic alveoli and bronchi. At the extreme edge active giant cell systems were prominent.

Comment. An infraclavicular round focus found on

mass radiography and showing no clinical evidence of activity apart from slight radiological enlargement.

CASE 11. M.G., a woman of 27, was admitted to a chest hospital in December 1952. In August 1952, following a cold which left her with a productive cough, and on account of the recent loss of two stones in weight, she was x-rayed and found to have a collapsed and consolidated area containing a cavity in the right upper zone (Fig. 11a.). Her sputum was positive for acid-fast bacilli. From September till December she was treated by streptomycin (90 G.) with P.A.S. but despite this her sputum remained positive.

On admission to a chest hospital in December she still had a trace of cough and sputum. There was some dullness and fine crepitations at the left apex. The B.S.R. which had been originally 26 mm. in the first hour had, by then, fallen to 2-3 mm.

Tomograms showed a roundish area of solid disease in the left upper zone in which central cavitation could still be seen (Fig. 11b.).

Bronchoscopy revealed no abnormality of the bronchial tree itself although a trickle of pus was seen exuding from the right upper lobe orifice.

On 30th January 1953, the apical segment of the left upper lobe, which contained the solid nodule, was resected.

In the specimen (Fig. 11c.), a solid mass of

caseous debris was found and related to it were caseous bronchi.

Comment. A case in which a cavity was seen to block. Although a translucency was seen in the pre-operative tomograms, no cavity was found in the specimen, which showed a solid mass of caseous matter to which tuberculous bronchi were related.

CASE 12. E.B. an Irish girl aged 18, came to nurse in London in March 1947. Her sister suffered from pulmonary tuberculosis. Routine radiograph revealed some diffuse shadowing in the right upper zone.

She carried on nursing under observation and remained well until November 1949, when there was some radiological extension of the disease. She was treated by bed-rest only and as no cavity was demonstrated by tomography or otherwise, she returned to nursing in August 1950.

Towards the end of 1952 she began to feel a little tired and developed a slight cough. The sputum was positive for acid-fast bacilli and radiologically a cavity was visible in the right upper zone.

She was admitted to a chest hospital. Her B.S.R. was 3 mm. in the first hour and all sputum tests were negative. On physical examination increased dullness was found at the right apex and a few crepitations were heard posteriorly.

Pre-operative bronchoscopy revealed no abnormality apart from a trickle of muco-pus from the right upper lobe orifice, and on tomography (Fig. 9a.) a uniform round shadow was seen in the 9 cm. cut.

Resection of apical and posterior segments of the right upper lobe was performed on 7th February 1953.

In the specimen a caseous nodule (Fig. 9b.) was situated distally to a tuberculous bronchus blocked by caseous debris. There was slight early excavation of the nodule.

Comment. A case in which a cavity developed in some diffuse shadowing and later blocked. In the specimen, in which a solid caseous mass related to a caseous bronchus was found, there was some evidence of early cavitation.

CASE 13. A.B., a girl of 18, was admitted to hospital in January 1953. Her father had had a thoracoplasty for pulmonary tuberculosis one year before.

Originally diagnosed in July 1949 when she was a symptomless contact of her father, she had been treated in a sanatorium from August 1949 until March 1951. In August 1949 there was considerable scattered disease in the right upper and mid-zones with a cavity in the second interspace (Fig. 13a.) and her sputum was negative for acid-fast bacilli. A right artificial pneumothorax was induced at that time but abandoned after a few weeks on account of extensive apical adhesions and she was then treated by graded rest. When discharged from the sanatorium in March 1951 marked clearing of the shadows in the right upper and mid zones had occurred, leaving a residual nodular shadow behind the first rib. This may have been a blocked cavity but it was difficult to say with certainty because of the distortion of pulmonary anatomy caused by the artificial pneumothorax.

She remained well and working until 1952,when the nodular shadow behind the first rib was seen to have enlarged and a new smudge shadow was seen in the second right interspace.

Because of these changes she was admitted to

hospital in January 1953. She was then symptomless but on examination dullness on percussion was elicited at the right apex, where fine crepitations were also heard. Her B.S.R. was regularly normal and acid-fast bacilli were never at any time found in her sputum.

In the tomograms at 4 cm. cut a moderately large homogenous opacity was seen with a small calcified lesion lateral to it (Fig. 13b.) "Tramlines" are not definite in this cut but suggestive shadows were seen in the more anterior cuts.

Bronchoscopy revealed no abnormality and thoracotomy was performed on 20th February 1953. Two solid lesions, one in the axillary area of the posterior segment and one in the apical segment of the right upper lobe, were found and both these segments were removed.

The specimen (Fig. 13 c.) showed a large nodule which was composed of very soft caseous material and which partly excavated during examination. The nodule was related to a caseous bronchus which appeared to be continuous with its capsule. There were also several smaller nodules the largest of which was a bronchial dilatation filled with soft caseous material and lying distal to a stenosed bronchus.

Comment. A nodule consisting of very soft material

and lying in relation to a caseous bronchus; it was probably a blocked cavity.

CASE 14. K.L., a housewife aged 27, had a left two stage thoracoplasty for pulmonary tuberculosis performed in December 1948.

When discharged from hospital in May 1949, her film showed a small "smudge" opacity in the right first interspace (Fig. 14a.) and although she remained well, serial radiography showed gradual enlargement of this "smudge" shadow until, by September 1951, the tomographic appearance suggested nodular disease (Fig. 14b.). She was treated by streptomycin (105 G.) with P.A.S. with no radiological change and in December 1952, was again admitted to hospital with a view to resection.

She was sputum free, sputum negative and had a normal B.S.R. On examination fine post-tussive crepitations were heard at the right apex.

One month after admission, she developed a cough with sputum which was positive for acid-fast bacilli. A postero-anterior film at this time showed extensive "soft" shadowing in the right upper and mid-zones (Fig. 14d.) and tomograms revealed a large cavity within the nodular lesion (Fig. 14c.).

Following a course of isoniazid (I.N.A.H.) and P.A.S. the disease settled down considerably and excision of the posterior segment of the right upper lobe was carried out on 18th March 1953. At operation

some nodules were felt in the apical and anterior segments but it was thought that lobectomy should not be done in view of the contralateral thoracoplasty.

In the posterior segment (Fig. 14e.) a nodule was seen which proved that the cavity seen in the tomograms had blocked. The related bronchus was blocked by tuberculous granulation tissue and the post-cavernous part of the bronchus was also tuberculous.

Comment. A case of a "smudge" shadow developing into a cavity which later blocked, in a woman with a contralateral thoracoplasty. In the specimen the nodule was related to an occluded, tuberculous bronchus.

CASE 15. E.C., an Irish girl, came to work in London in May 1951. She was a delicate girl who had had three attacks of pneumonia in childhood and was only a few days in London before she contracted rheumatic fever.

She had done some nursing in an Irish sanatorium in 1950 but before she started, it had been necessary to give her B.C.G. vaccine as her Mantoux test was negative.

In December 1951 she developed a cough with blood-stained sputum, retro-sternal pain and fatigue. These symptoms persisted until March 1952 when she was x-rayed and pulmonary tuberculosis diagnosed. Her film showed extensive "soft" shadowing at the right base, with a possible cavity present (Fig. 15a.). She was treated by streptomycin (78 G.) and P.A.S. and by a right phrenic crush followed by induction of a pneumoperitoneum.

This treatment was effective in obtaining sputum conversion and tomograms taken after her admission to a chest hospital in August 1952 showed a solid lesion with a rather indefinite central clearing (Fig. 15b.).

She felt well although she still produced occasionally some blood-flecked sputum. No abnormal physical signs were found.

In March 1953 the sputum again became positive for

acid-fast organisms.

Thoracotomy was performed on March 20th and the lateral basal segment of the right lower lobe was found to be atelectatic and was removed.

Examination of the specimen showed that the main nodule (Fig. 15c.) was related to caseous bronchi and several smaller caseous foci were seen.

Comment. A case of an Irish girl who, one year after being successfully vaccinated with B.C.G., developed pulmonary tuberculosis. A cavity, which was present in an area of exudative disease, was seen to block and the specimen showed a solid mass related to tuberculous bronchi.

CASE 16. M.C., a housewife aged 25, who had associated with a tuberculous colleague for about a year, developed a feeling of lassitude during the summer of 1952. In September she began to cough and shortly afterwards had a haemoptysis of a few ounces.

She was admitted to hospital as an emergency and treated by streptomycin (70 G.) and P.A.S. At that time her radiograph showed ill-defined "soft" shadowing in the right upper zone (Fig. 16a.) which was proved by lateral tomograms to be partly due to atelectasis of the posterior segment (Fig. 16b.) It was doubtful whether there was a cavity within this area.

She was transferred to a chest hospital in March 1953, still with slight cough and lassitude, but her B.S.R., which had originally been 73 mm. in the first hour, had fallen to 5 mm. and the sputum remained persistently negative for acid-fast bacilli. The only abnormal finding in her chest was an impaired percussion note in the right infraclavicular area.

The routine radiograph showed that there had been considerable clearing of the shadows in the right upper zone and there remained a round shadow behind the first rib, confirmed by tomography (Fig. 16c.).

At thoracotomy on 22nd May the apical and posterior segments were both diseased and therefore were removed.

The posterior segment (Fig. 16d.) was collapsed and contained a large encapsulated caseous nodule and several smaller ones. The bronchi in relation to the caseous foci were crowded, dilated and tuberculous.

Comment. A nodule which became visible when an area of exudative shadowing cleared. In the specimen the nodule was present in a collapsed segment and the related bronchi were crowded, dilated and tuberculous.

CASE 17. H.J. a woman of 56, with no family or contact history of tuberculosis, complained of fatigue and loss of weight, in October 1952. Some years before she had had a left sided pleurisy but apart from this had always been a healthy woman.

She presented herself for mass radiography in October 1952 and this revealed infiltration in the left upper zone with a fairly large cavity behind the first rib (Fig. 17a.). She was treated by postural retention and by streptomycin (30G.) and P.A.S. The fluid level in the cavity was observed in serial radiographs to rise gradually until the cavity was completely filled (Figs. 17b, 17c and 17d.). This was the state of affairs when she was admitted to a chest hospital in April 1953. She was well and symptomless, sputum negative and had a normal B.S.R. Some fine rales were heard at the left apex.

In June 1953, the apical and posterior segments of the left upper lobe were resected. The large focus was found to be in the apical segment and several small foci were seen in the posterior segment.

In the specimen (Fig. 17e.) a large focus was seen, the basic structure of which was no longer discernable. In addition there were many smaller foci associated with areas of collapse and tuberculous

bronchitis.

Comment. A blocked cavity in which the blocking was observed in serial radiographs.

CASE 18. B.B., an Irish woman of 26, came to live in London in November 1951. While doing domestic work in a hospital, a routine radiograph revealed a large tension cavity in the right lower lobe (Fig. 18a.). She stated that she had had a cough and sputum for three months previously but was not otherwise ill. She was treated by streptomycin and P.A.S. followed by a pneumoperitoneum with a right phrenic crush before being admitted to a chest hospital in February 1953.

At that time she still had some cough and sputum which, although positive initially, had become negative for acid-fast bacilli. The B.S.R. was 10 mm. in the first hour. There was a slight impairment of the percussion note at the right base posteriorly, and some crepitations were heard in that area.

The radiograph taken on admission showed that the cavity was still present although reduced in size: treatment by chemotherapy and pneumoperitoneum was, therefore, continued.

By May the cavity was no longer visible on the postero-anterior radiograph, but lateral tomograms revealed it as a rather "solid" lesion with a smallish central cavity (Fig. 18b.). In view of this finding the pneumoperitoneum was abandoned and resection of the right basal segments was performed on 19th June.

As anticipated the specimen (Fig. 18c.) showed a cavity in a solid diseased area, which was related to tuberculous bronchi.

Comment. A blocked cavity which never became completely solid and in which excavation was observed pathologically. The related bronchi were tuberculous.

CASE 19. M.B., a male student, aged 22, who suffered from bronchitis as a child, complained of a cough in November 1952. A chest radiograph revealed a thick-walled cavity behind the left second rib (Fig. 12a.) and a specimen of his sputum contained acid-fast bacilli. A mass radiography film, one year previously, had revealed no abnormality.

He was treated by streptomycin (30 G.) with P.A.S. and an unsuccessful attempt was made to induce a left artificial pneumothorax. Tomograms taken in February 1953 revealed a nodular shadow but no cavity (Fig. 19b.).

While convalescing, tomograms of the left upper zone were repeated and it was observed that a definite cavity had appeared within the nodular lesion (Fig. 19c.). He was then admitted to a chest hospital for treatment.

On admission he was symptomless, there were no abnormal physical signs in the chest and his B.S.R. was 4 mm. in the first hour. His sputum was repeatedly positive for acid-fast bacilli.

Bronchoscopy, on 3rd July 1953, was normal and on 10th July 1953, the apical and posterior segments of the left upper lobe were resected. A radiograph taken just before operation failed to show a cavity in the round shadow and it was assumed that the cavity had blocked for the second time.

In the specimen (Fig. 19d.) a large caseous nodule was seen in relation to a caseating bronchus.

Comment. A case of a cavity which blocked, re-opened and re-blocked before it was finally resected.

CASE 20. N. O'N., an Irish girl of 31 years, was admitted to hospital in April 1953.

Since 1948 she had suffered from amenorrhoea for which no cause could be found. During the summer of 1950, she underwent a mass radiography examination because of some loss of weight. Pulmonary tuberculosis was diagnosed. Unfortunately this film could not be traced and because of a misunderstanding she did not come under continuous observation until January 1951. A radiograph at this time revealed nodular disease surrounded by diffuse shadowing in the right upper zone. An area suspicious of cavitation developed behind the right first rib. Later films showed a round homogeneous shadow in the site of this possible cavity and this was confirmed by tomograms taken in July 1951 (Fig. 20a.).

She remained well until January 1953, when a cavity was seen to have replaced the round shadow (Fig. 20b.). After a short course of chemotherapy she was admitted to a chest hospital where the sputum was found to contain acid-fast bacilli and the B.S.R. was raised to 9 mm. and later to 18 mm. in the first hour. On physical examination, there was an area of bronchial breathing at the right apex.

With continued rest and chemotherapy the cavity became smaller and eventually presented again as a

nodular shadow, verified by tomography (Fig. 20c.).

Bronchography (Fig. 20d.) revealed some collapse of the apical and posterior segments.

Following a bronchoscopy which revealed no abnormality a right upper lobectomy was performed in July 1953.

The specimen (Fig. 20d.) revealed a soft spherical focus, which consisted of amorphous caseous material. It was related to a caseating bronchus.

Comment. A case in which a nodule was observed in an area of diffuse shadowing. Later a cavity developed, blocked, re-opened and re-blocked before being finally resected.

CASE 21. H.C., an Irish woman aged 31, with no family or contact history, complained of fatigue during the summer of 1952, and in the following December developed pleuritic pain and dry cough.

A radiograph revealed a hazy "soft" shadow in the fourth right interspace (Fig. 21a.). A laryngeal swab, taken at this time, grew tubercle bacilli on culture.

Following treatment by streptomycin (24 G.) and P.A.S. she was admitted to a chest hospital in April 1953. She was symptomless, her sputum was negative and her B.S.R. was 5 mm. in the first hour. There were no abnormal findings in the chest.

A radiograph showed that much of the haziness had cleared from the original opacity and that it was slightly more circumscribed. Lateral tomography showed a clearly defined round shadow probably situated in the sub-apical segment of the right lower lobe (Fig. 21b.).

Bronchoscopy revealed no abnormality and thoracotomy was performed in July 1953. A retrograde, subsegmental resection of the area containing the nodule was done.

The wedge shaped specimen (Fig. 21c.) showed an encapsulated caseous pneumonitis with a tuberculous

bronchus, filled with caseous debris, at its apex. A pleural dimple, caused by atelectasis distal to the nodule, was seen.

Comment. A caseous nodule which emerged from a clearing area of exudative shadowing. At no time was cavitation seen radiologically, nor was it seen in the specimen. The related bronchus was tuberculous and occluded by caseous debris.

CASE 22. D.P., a woman of 38, who had helped to nurse her sister suffering from pulmonary tuberculosis, was herself x-rayed as a contact in June 1951. The film showed a small area of diffuse shadowing in the right mid-zone. A second film one month later showed a definite cavity and this was confirmed by tomography (Fig. 22a.). A laryngeal swab culture at this time grew tubercle bacilli (The only positive result in her case).

She was quite well and symptom free. She was treated by streptomycin and P.A.S. and a right phrenic crush and a pneumoperitoneum, and in September a homogeneous opacity of roughly the same shape as the cavity was seen replacing it (Fig. 22b.). No further radiographic change occurred until lateral tomograms were taken in June 1953. These suggested an area of central translucency within the shadow. The patient was therefore admitted to hospital although she was still well and sputum negative. Her B.S.R. was consistently normal and there were no abnormal physical findings. Bronchoscopy was not done in this case and thoracotomy was carried out on 7th August 1953. The nodule was felt in the apical segment of the right lower lobe and was removed by wedge resection, no obvious bronchial communication

being encountered.

The nodule (Fig. 22c.) showed an encapsulated nodule, mottled by carbon pigment. The central core was of soft consistency. In this specimen a pleural dimple, caused by atelectasis distal to the nodule, was seen.

Comment. A case in which a cavity developed in an area of exudative disease and later blocked.

CASE 23. D.M., a healthy woman of 34, volunteered for mass radiography examination in April 1951 and a small nodular shadow was noted in the first left interspace. By October the nodule was more definite and she was kept under chest clinic supervision, although she was well and symptomless.

In June 1952 the shadow had enlarged and was seen on tomography to have a triangular shape (Fig. 23a.).

In February 1953 tomograms showed the lesion to be larger still and to have an area of translucency within it (Fig. 23b.) A laryngeal swab grew tubercle bacilli at this time. In June a cough with sputum developed and was associated with still further enlargement of the focus and with more definite evidence of cavitation within it (Fig. 23c.). Post-tussive crepitations were audible at the left apex posteriorly.

In view of this she was admitted to hospital and thoracotomy was performed in August 1953. Probably as a result of treatment with streptomycin and P.A.S., the nodule had become smaller, but it was still clearly felt in the posterior segment of the left upper lobe. This segment was resected.

In the specimen (Fig. 23d.) a partially cavitated nodule was seen in relation to a partially occluded bronchus.

Comment. A caseous nodule which gradually enlarged and later cavitated. A cavitated nodule was seen in the specimen and it was related to a partially occluded tuberculous bronchus.

CASE 24. J.B., a young woman of 21, with no significant past or family history, developed pain in the left side of the chest in January 1953. A radiograph showed a round, homogeneous opacity in the third left interspace. She was treated by streptomycin (15 G.) and P.A.S. and by a left phrenic crush.

When admitted to hospital on 6th March, she felt well and no abnormal signs were discovered in her chest. A radiograph taken on admission suggested that the shadow had become smaller since January 1953 but in June, despite continuation of chemotherapy, it underwent slight enlargement again. Simultaneously, the B.S.R. rose from 5 mm. to 15 mm. in one hour.

Tomograms taken shortly after her admission revealed, within the shadow, an eccentric area of translucency which appeared to be in direct continuity with "tramlines" to the hilum (Fig. 24a.).

At no time were tubercle bacilli isolated from her sputum. Bronchoscopy failed to show any abnormality and at operation on 28th August, the nodule was felt in the axillary area of the anterior segment of the left upper lobe. It was removed by wedge resection.

The nodule (Fig. 24b.) was an encapsulated focus of caseous pneumonitis in which early excavation was seen. The related bronchus was tuberculous.

Comment. A caseous nodule which was fully formed when first seen; it was thought to be cavitating. In the specimen, the nodule, which was related to a tuberculous bronchus, showed evidence of early excavation.

CASEOUS NODULES OF THE LUNG.

OBSERVATIONS ON TWENTY - FIVE CASES TREATED BY RESECTION.

VOLUME 2 - ILLUSTRATIONS.

NOTE CONCERNING RADIOGRAPHS.

All radiographs were taken at a tube-casette distance of six feet and in the postero-anterior projection.

The measurements given in reference to the antero-posterior tomograms are in centimetres from the back, while those in reference to the lateral tomograms are in centimetres from the lateral chest wall of the side examined.

CASE NO 1.

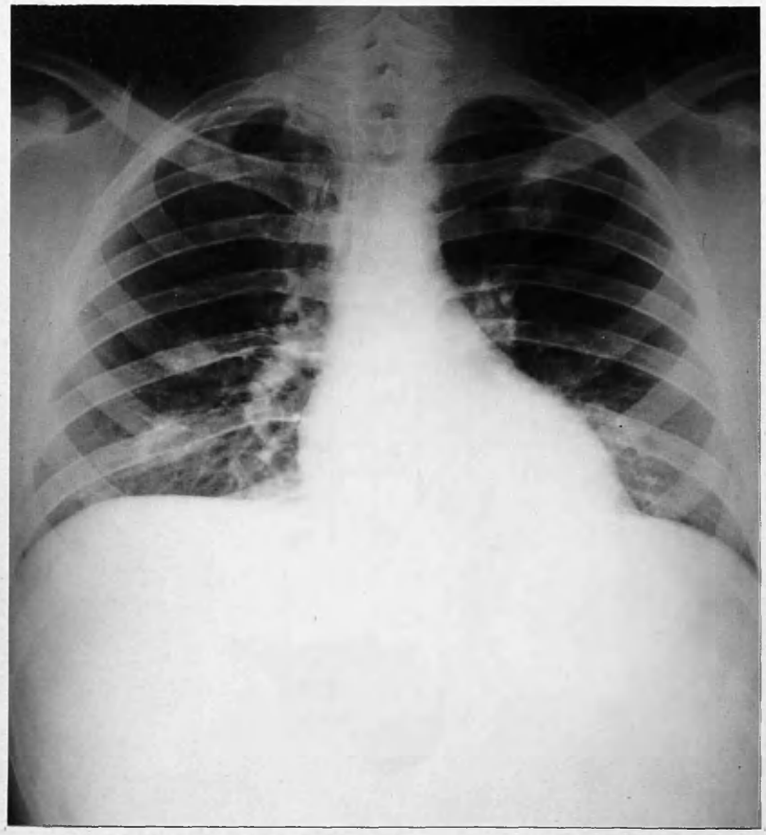


Fig. 1a. - Radiograph of chest taken on 24.12.51., showing a round shadow with central translucency, behind the anterior end of the left first rib. Note the "tramlines" to the hilum and the linear shadow in the first intercostal space. The two ill-defined opacities in the right mid-zone were revealed on tomography as nodular foci also.

Fig. 1b. - Tomogram through the left upper zone at 8cm. depth, taken on 2.1.52., showing that, in fact, the nodule is not round but rather irregular in shape and that the translucency is slightly eccentric in position. The "tramlines" are not seen clearly in this cut, but the linear shadow is well shown and represents an old-standing area of atelectasis distal to the nodule.

CASE NO. 2.

Fig. 2a.- Tomogram through the right upper zone at 4cm. depth, taken on 29.2.52., showing a dense homogeneous nodule with a satellite shadow situated below and lateral to it. The satellite nodule is surrounded by diffuse shadowing. The large nodule appears, at first glance, to have no evidence of translucency within it, but on closer scrutiny an area of clearing can be seen on its lower edge: this clearing may possibly be in communication within rather poorly defined "tramlines." The latter can be seen clearly in the 5cm. cut (not reproduced.)

CASE NO. 3.

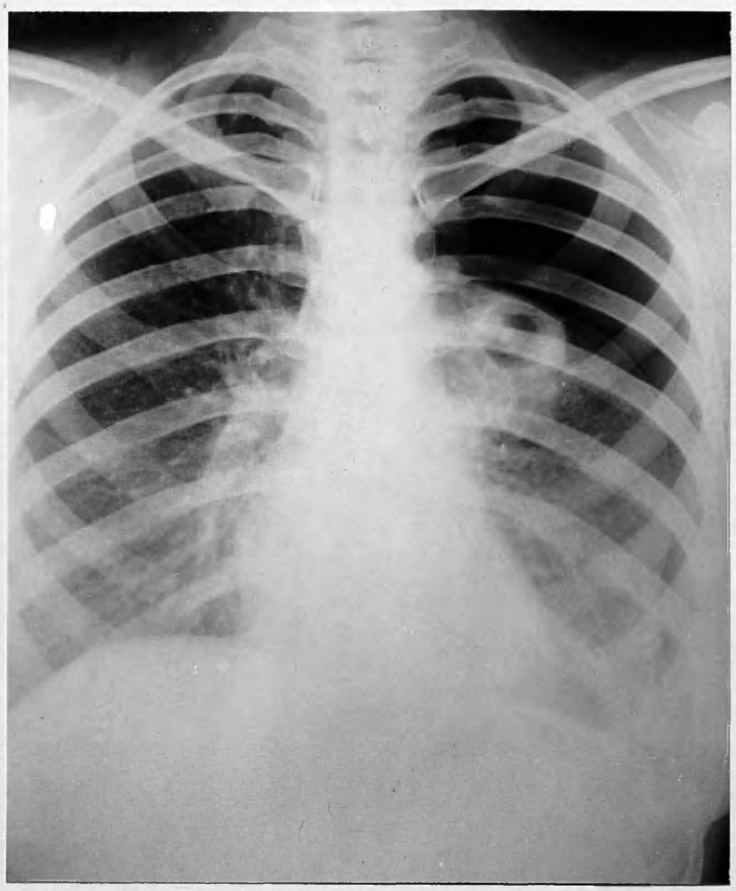


Fig. 3a. - Radiograph taken on 22.1.52. showing a large cavity still present in an atelectatic left upper lobe, despite treatment for six months by artificial pneumothorax.

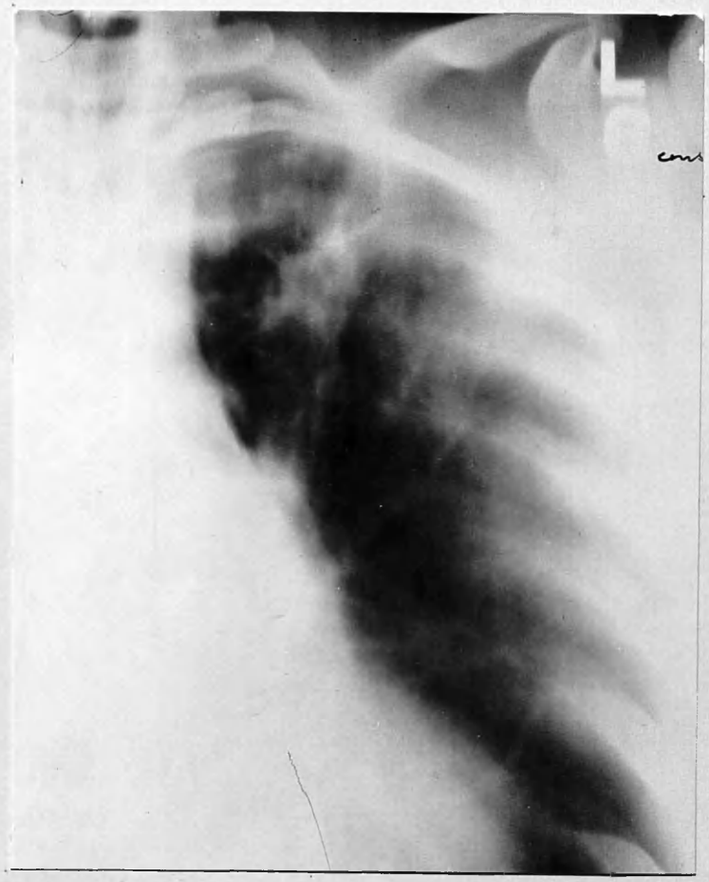
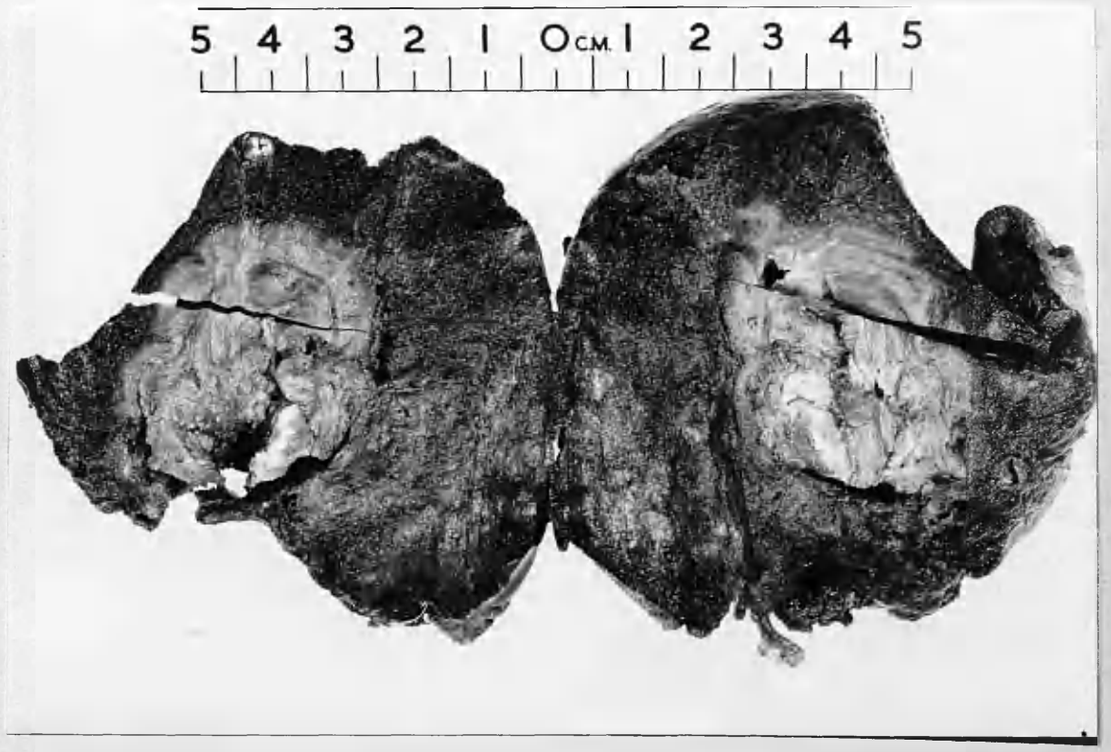


Fig. 3b. - Tomogram of the left upper zone at 6cm. depth, taken on 1.4.52., after the lung had re-expanded, showing that the cavity seen in Fig.3a. has been replaced by an irregular solid focus with a central area of translucency. "Tramlines" are visible though ill-defined. Several linear projections from the body of the focus, representing small areas of atelect-asis, are clearly seen.

CASE NO.4.

Fig. 4a. - Tomogram of the left upper zone at 7cm. depth, taken on 16.1.52., showing a large solid nodule, densely calcified in part, with a semi-circular area of translucency in its lower half. There is also some evidence of atelectasis and in the tomogram 1cm. anterior to this one "tramlines" were seen establishing continuity with the semi-circular cavity. Note the satellite focus.



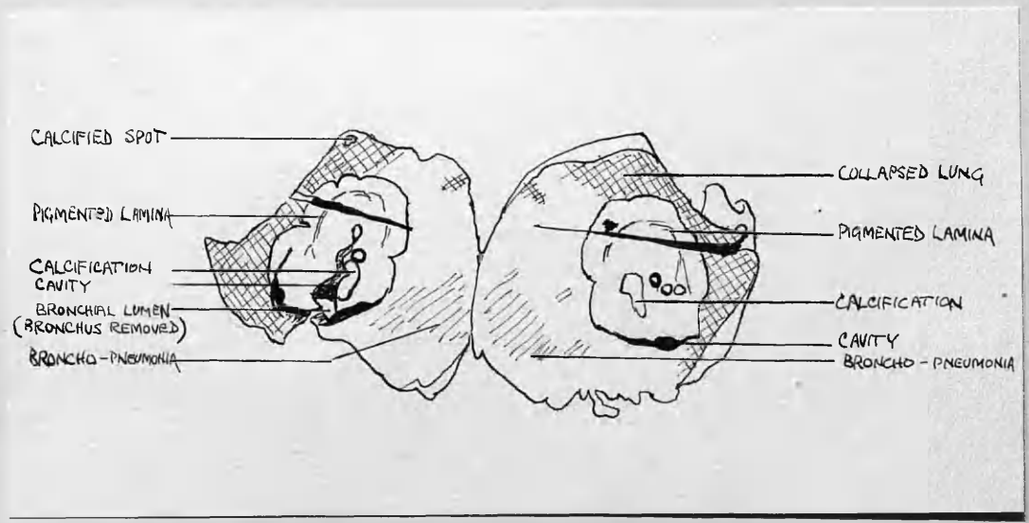


Fig. 4b.- The resected specimen in this case.

CASE NO. 4.

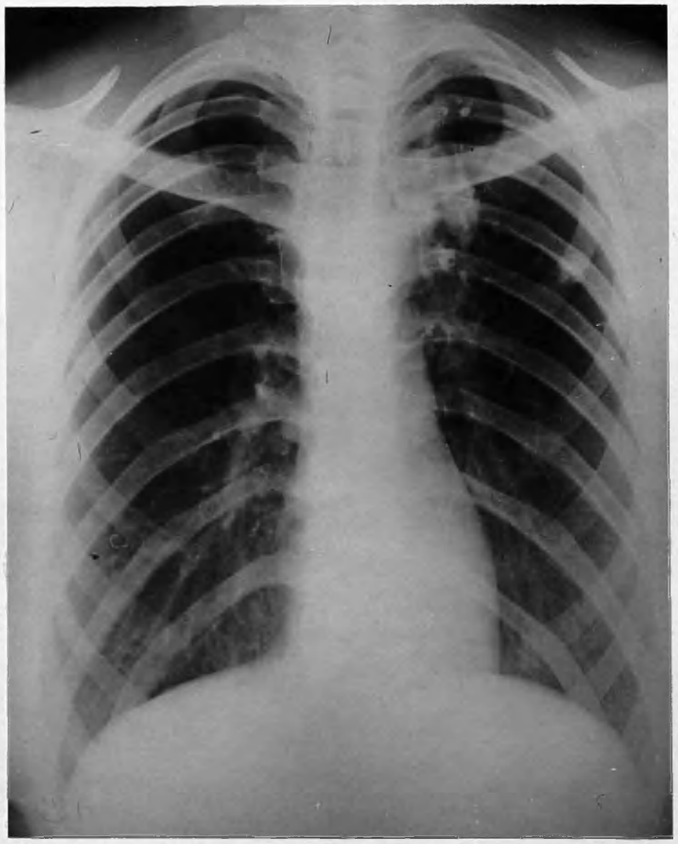


Fig. 4c. - Radiograph of chest taken on 31.12.51., showing the large, partly calcified nodule in the left upper zone and the satellite focus behind the left second rib.

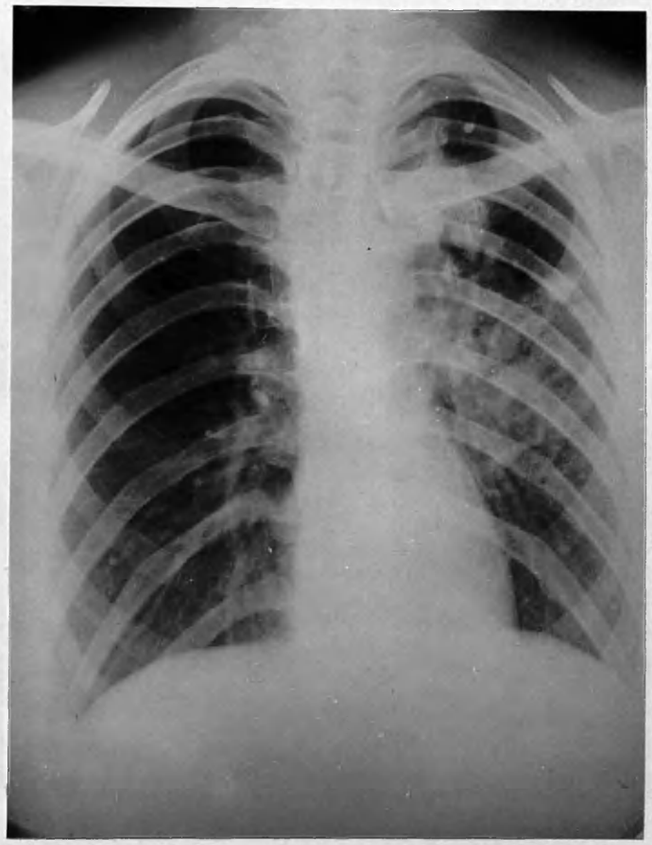


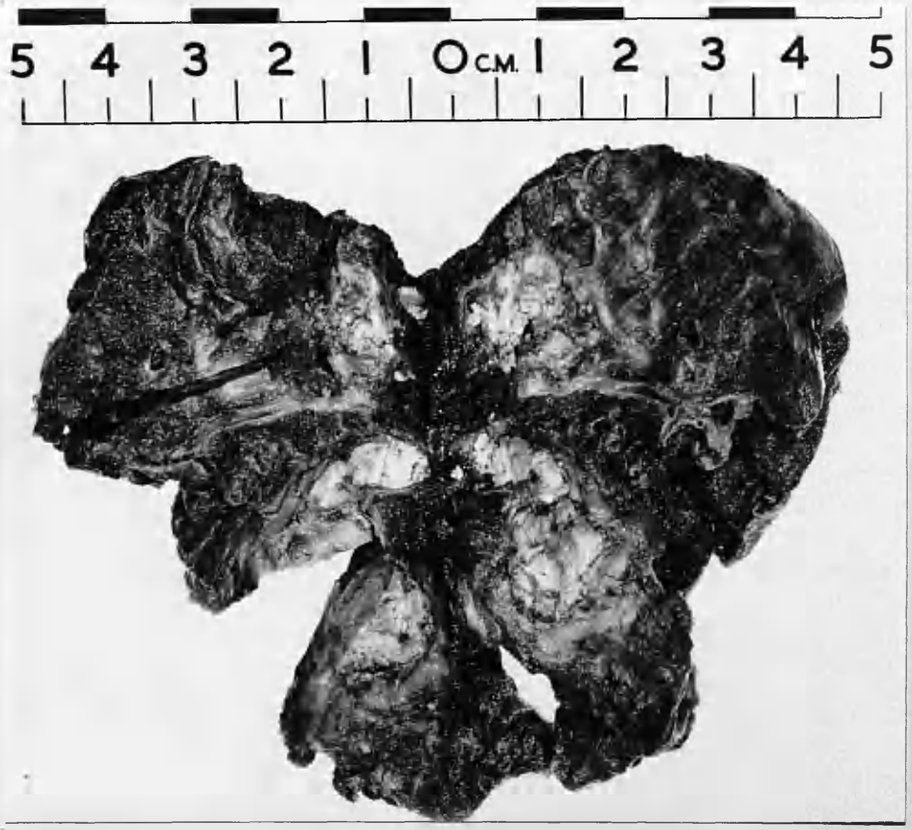
Fig. 4d. - Radiograph taken on 26.1.52. There is now widespread, diffuse shadowing in the left mid- and lower zones, representing acute bronchogenic dissemination of the disease. In this case such an incident occurred on three occasions before the lesion was finally resected.

CASE NO. 5.

1st. operation - left upper lobe segmentectomy.

Fig. 5a. - Tomogram at 6cm. of both upper zones, taken on 18.9.52. On the left there is a round shadow with a central translucency, the edge of which is clearly defined. "Tramlines" can be seen extending from the hilum to this shadow. Below and lateral are two satellite foci, the smaller of which is partly calcified.

On the right is a wedge-shaped opacity probably representing a segmental atelectasis.



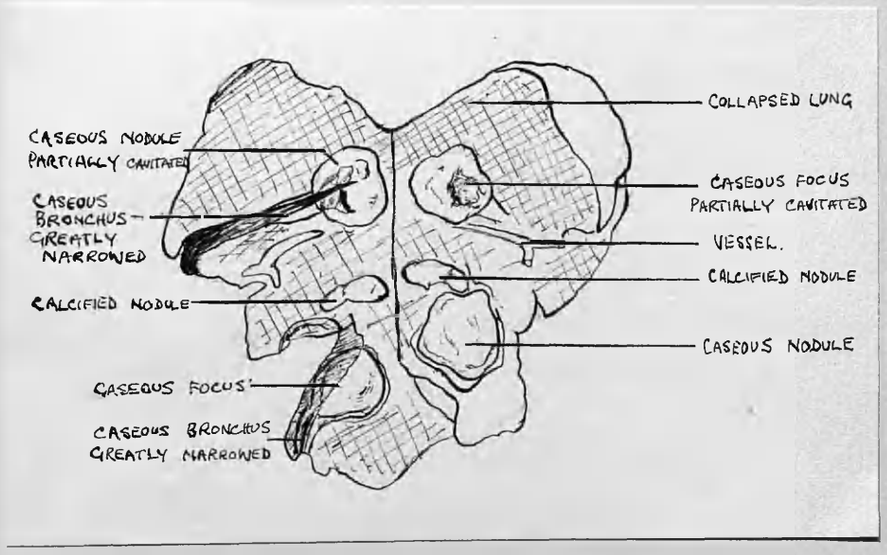


Fig. 5b.- The resected specimen.

CASE NO. 5.

2nd. operation - right upper lobe segmentectomy.

Fig. 5c. - Tomogram of the right upper zone at 8cm., taken on 17.4.53. There is a nodular lesion with a central area of translucency and well marked "tramlines" to the hilum. (Compare Fig. 5a.)

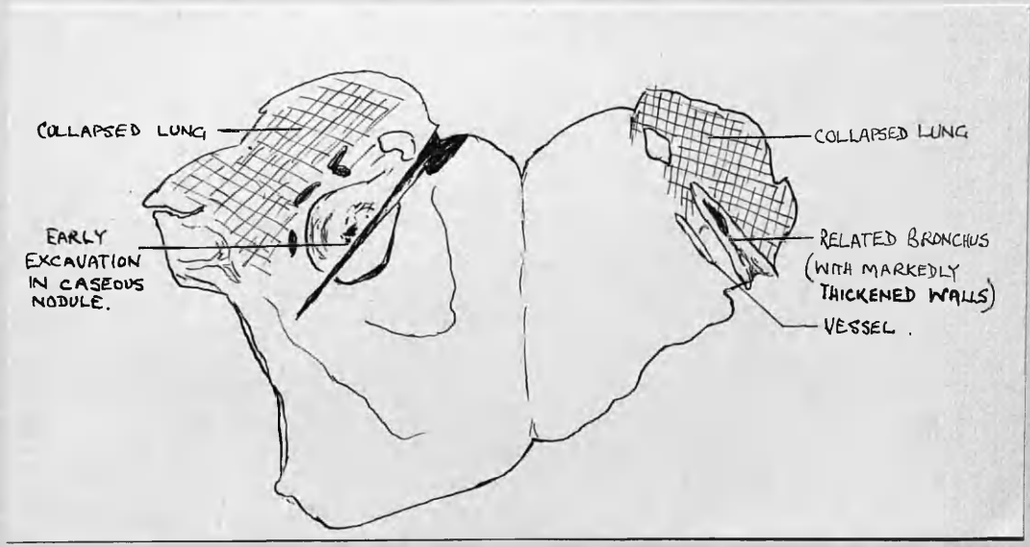


Fig. 5d. - The resected specimen.

CASE NO. 6.

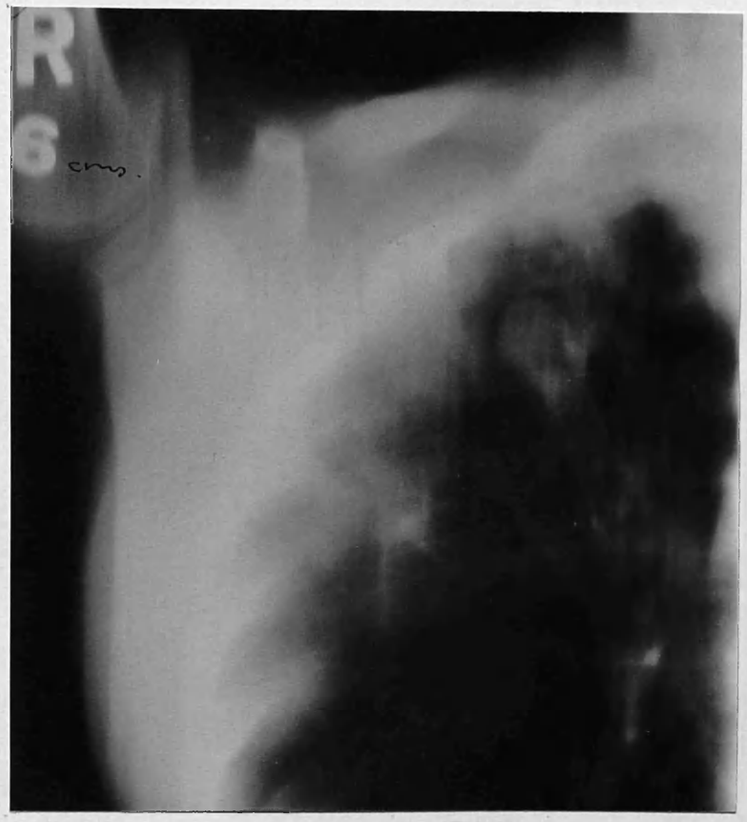


Fig. 6a. - Tomogram of the right upper zone at 6cm., taken on 15.7.52. There is an oval shaped shadow with a central clearing. "Tramlines" are well seen, and there is some diffuse shadowing distal to the oval focus.

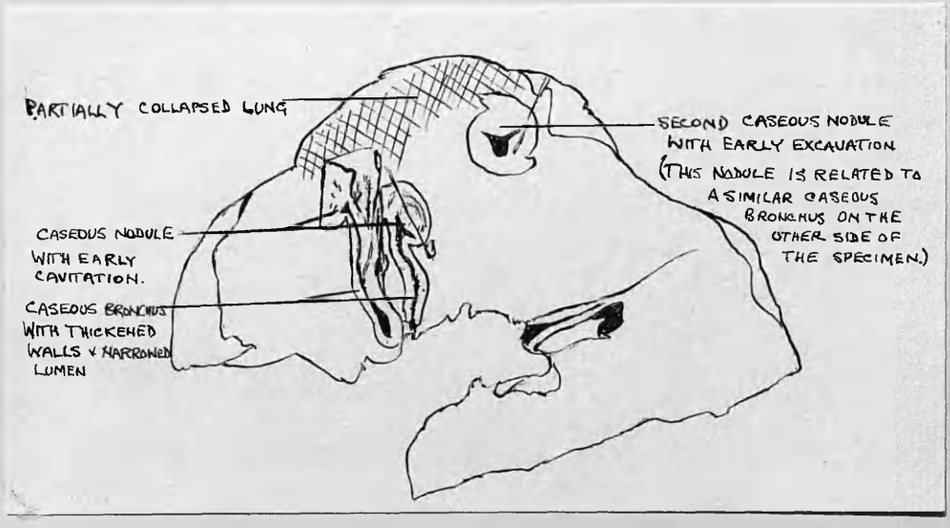


Fig. 6b.- The resected specimen

CASE NO. 7.

Fig. 7a. - Tomogram of the right upper zone at 8cm., taken on 14.10.52., showing a clearly-defined, irregularly-shaped nodule of even density throughout. There are also some calcified lymph-nodes in the hilar region.

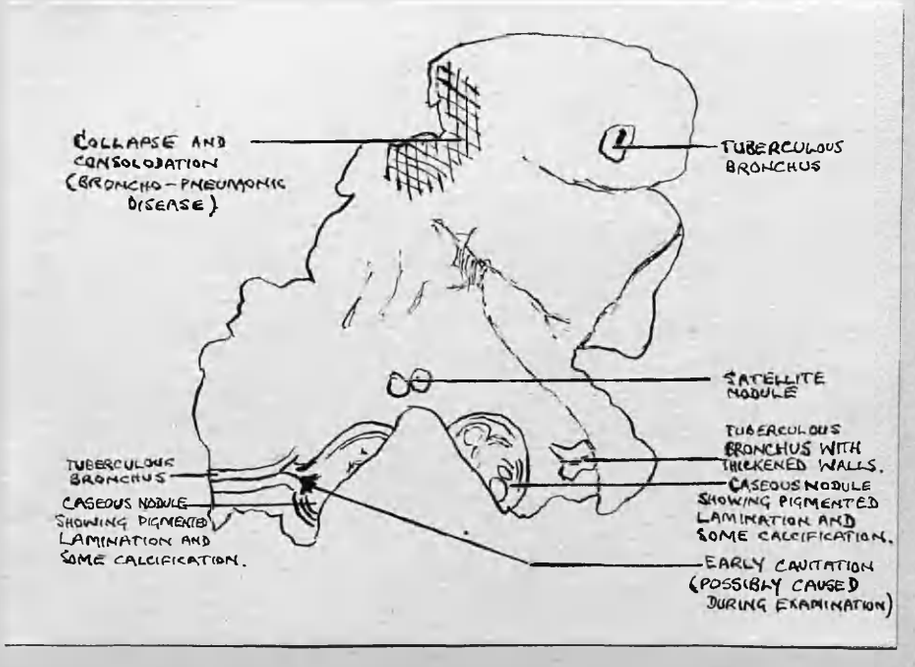


Fig. 7b. - The resected specimen.

CASE NO. 8.

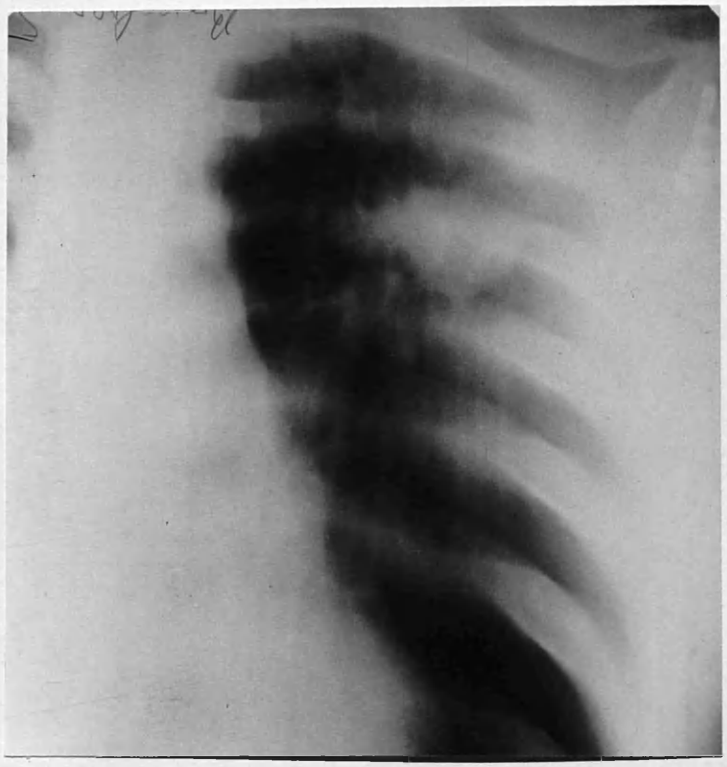


Fig. 8a. - Tomogram of the left upper zone at 5cm., taken on 23.10.52. There is an irregularly-shaped focus with some linear shadowing peripherally and some doubtful evidence of bronchial disease between it and the hilum.

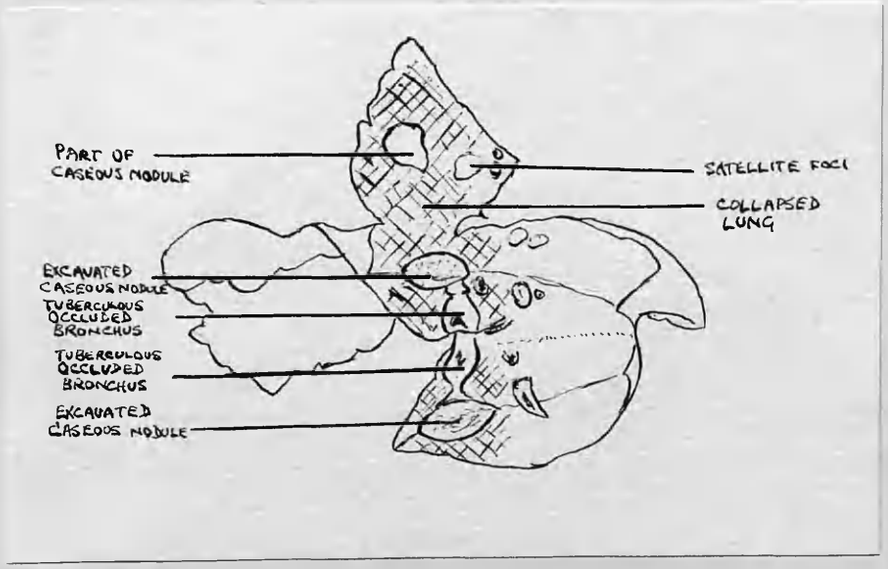


Fig. 8b. - The surgical specimen.

CASE NO. 9.

Fig. 9a. - Tomogram of the right upper zone at a depth of 7cm., taken on 5.11.52. An irregular solid focus can be seen. In its upper part there is a well marked translucency which was mistaken for a cavity and subsequently proved to be an emphysematous bulla.

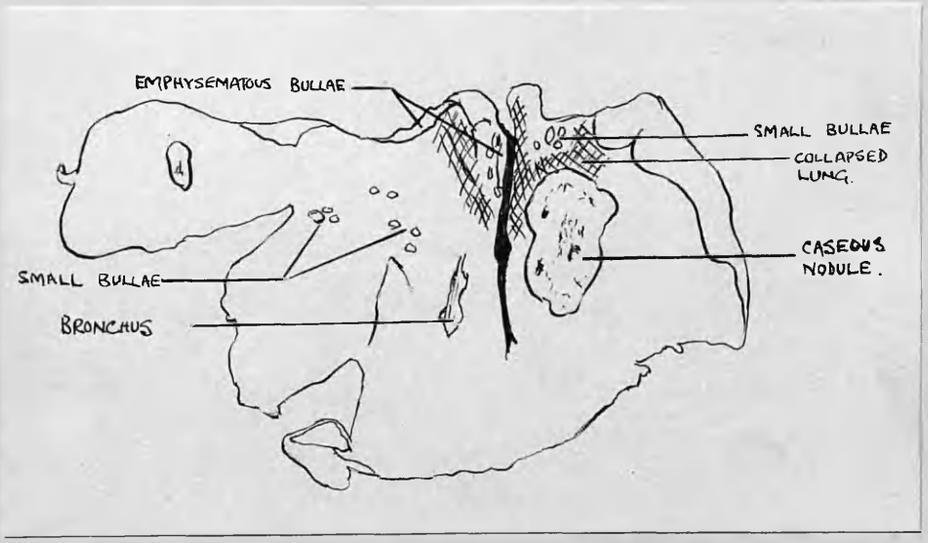


Fig. 9b. - The surgical specimen.

CASE NO. 10.

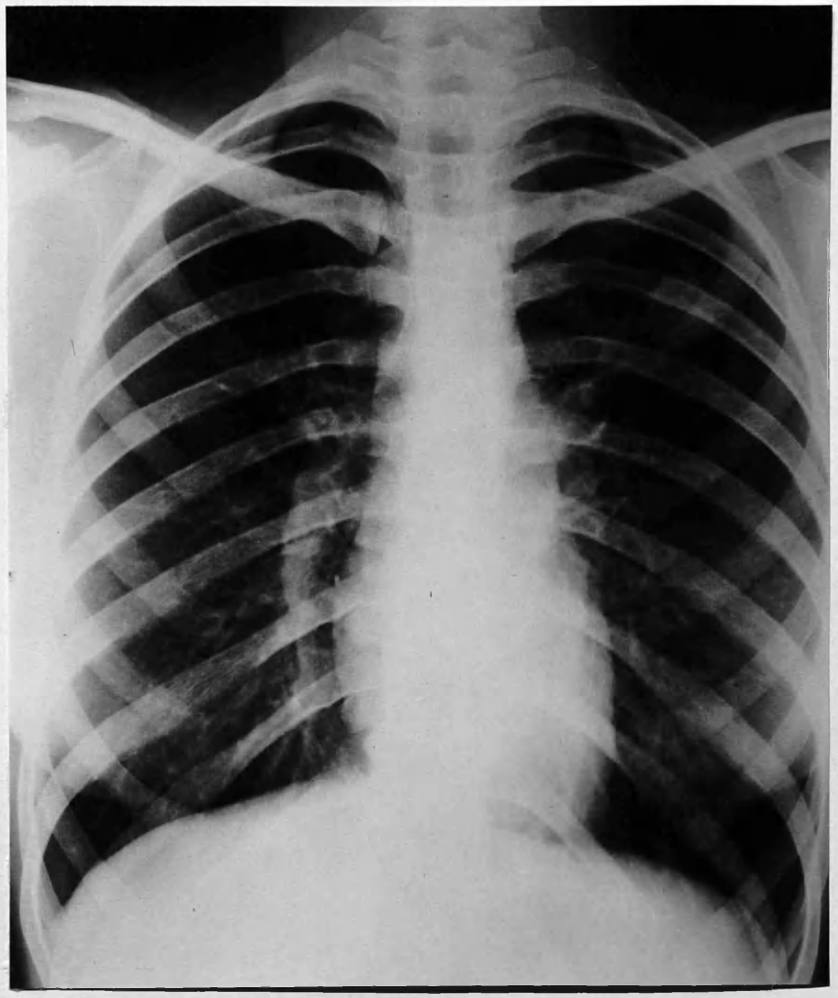


Fig. 10a. - Radiograph of chest taken 21.10.52. A typical infraclavicular round focus is seen in the first left intercostal space anteriorly.

CASE NO. 11.

Fig. 11a. - Lordotic view of the right apex taken on 5.8.52., showing a cavity in a collapsed and consolidated area.

Fig. 11b. - Tomogram of the right upper zone at 4cm., taken on 15.12.52. Though reduced in size, the cavity is still faintly visible within a nodular type of opacity.

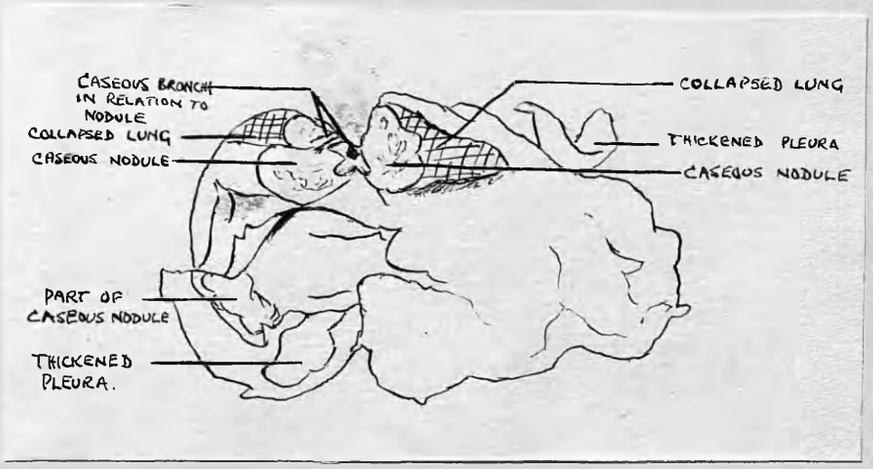
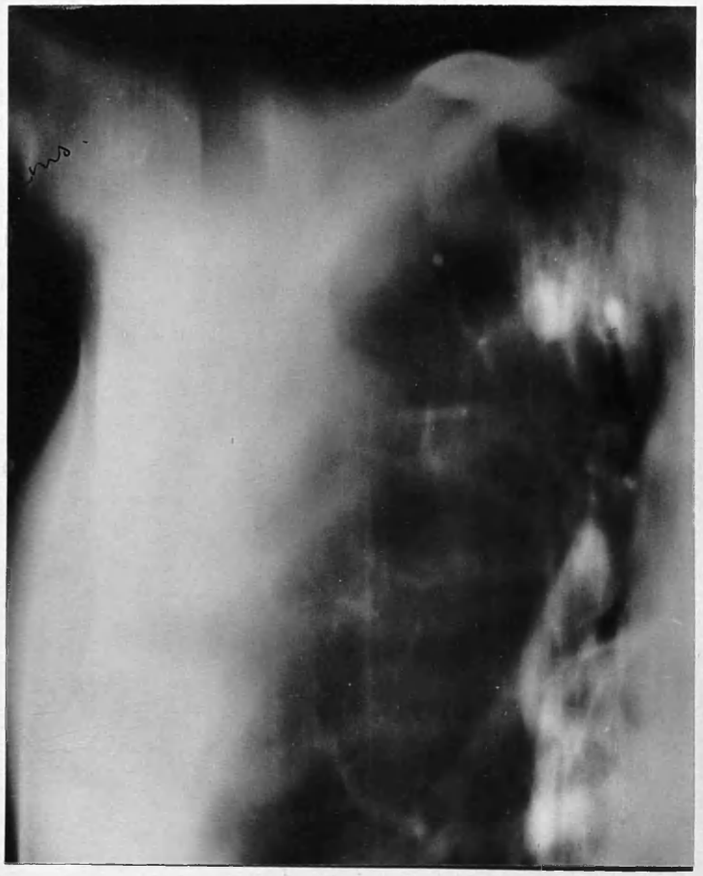


Fig. 11c. - The resected specimen.

CASE NO. 12.



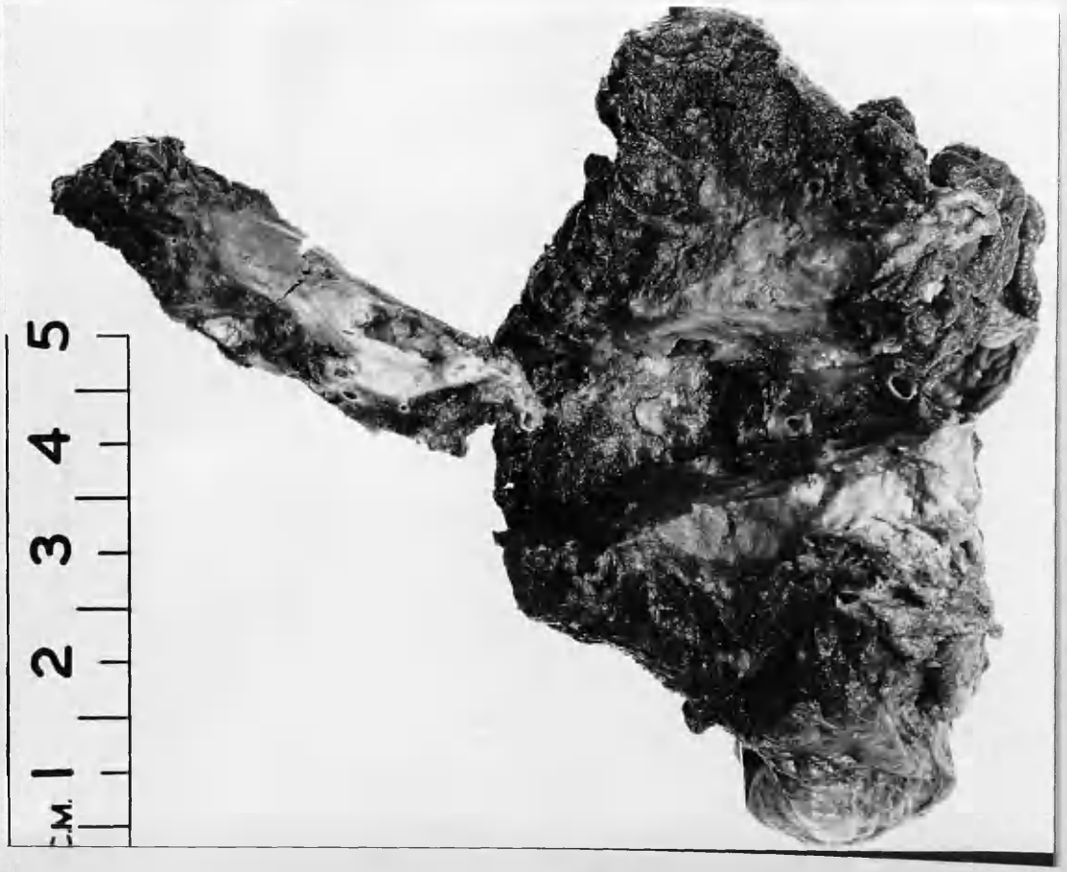


Fig. 12a. - Tomogram through the right upper zone at 9cm. depth, taken on 23.12.52., showing a dense round shadow with some ill-defined shadowing peripheral to it. There are also some linear streaks directed towards the hilum. Although not typical "tramlines" these are at least suspicious of bronchial disease.

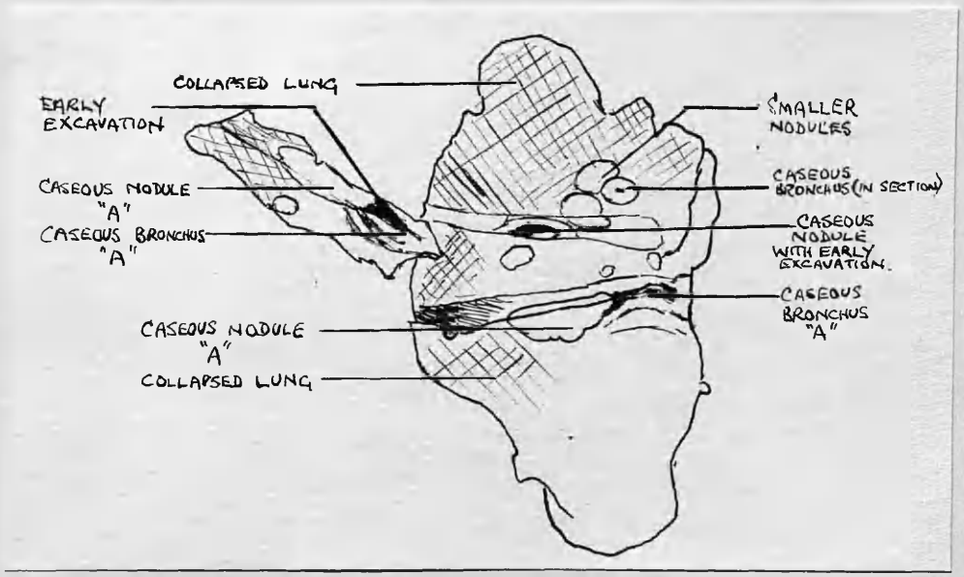


Fig. 12b. - The resected specimen.

CASE NO. 13.

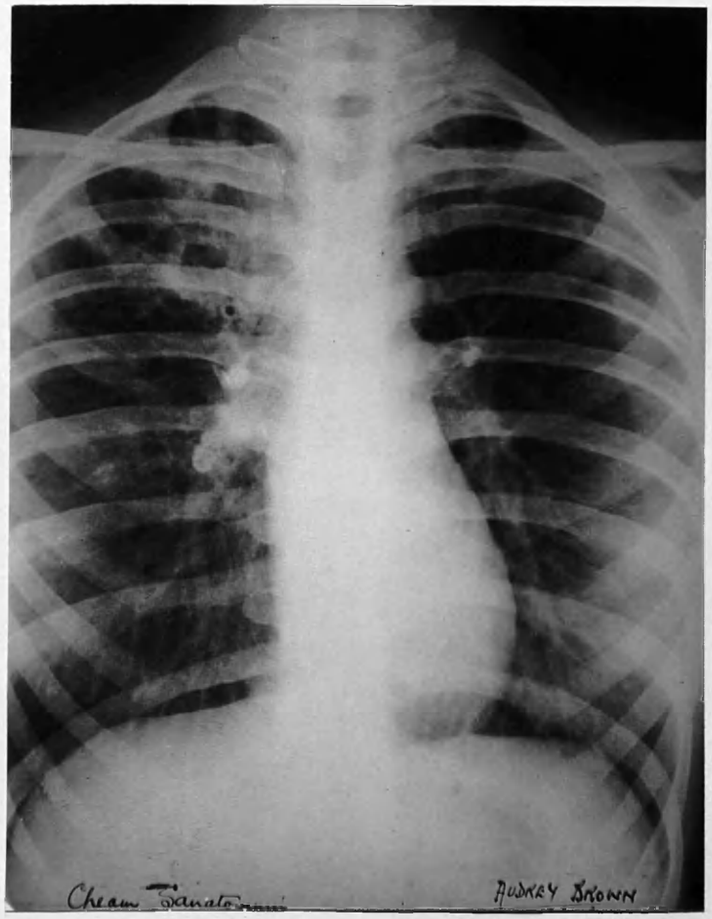


Fig. 13a. - Radiograph of 13.9.49. There is diffuse shadowing in the right upper and mid-zones, with a cavity in the first intercostal space anteriorly. Calcified areas are seen in both hilar regions, particularly the right.

Fig. 13b. - Tomogram through the right lung at 4cm., taken on 28.1.53. There is now a solid nodule in the right upper zone, with an area of clearing in its medial part. The "blocking" of the cavity occurred while an unsuccessful artificial pneumothorax was being tried in July 1950. There are some calcified satellites present and a well-marked primary complex in the mid-zone.

CASE NO. 13.

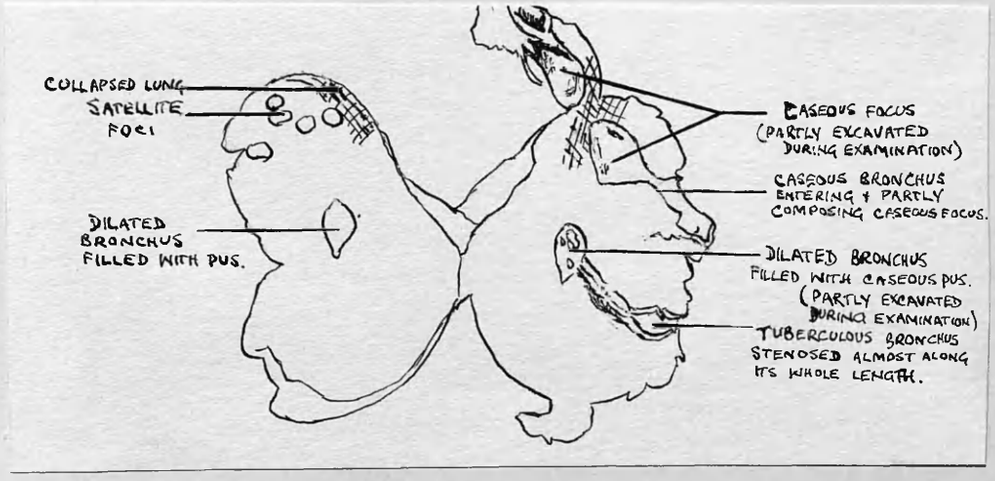


Fig. 13c. - The surgical specimen.

CASE NO. 14.

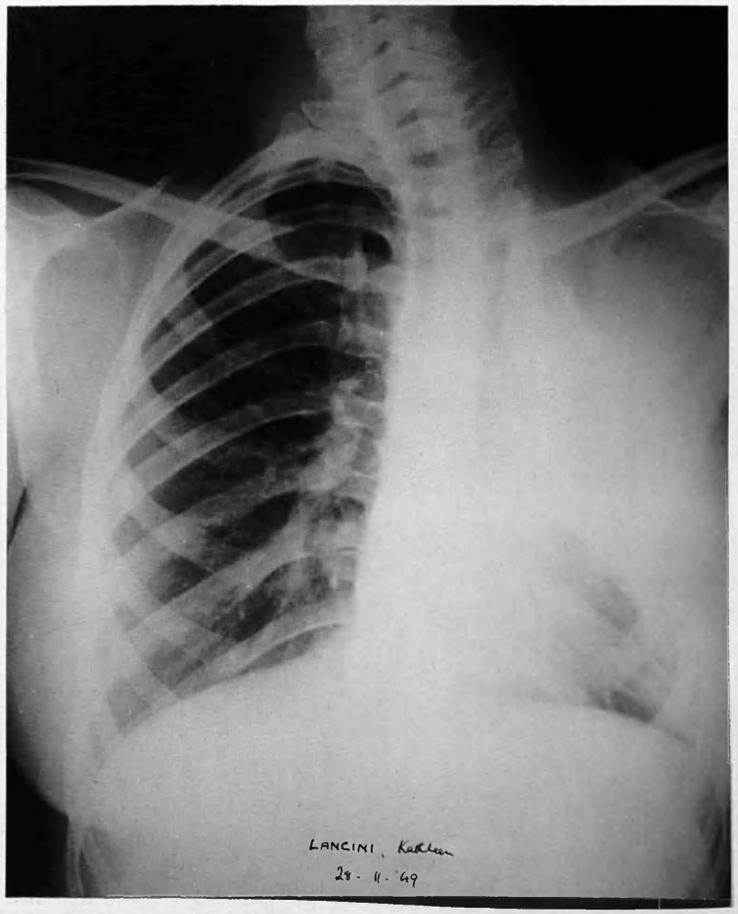


Fig. 14a. - Radiograph of chest taken on 28.11.49., eleven months after a two-stage thoracoplasty had been performed for persistant cavitated disease in the left upper lobe. There is a small,hazy "smudge" shadow in the first right inter-costal space.

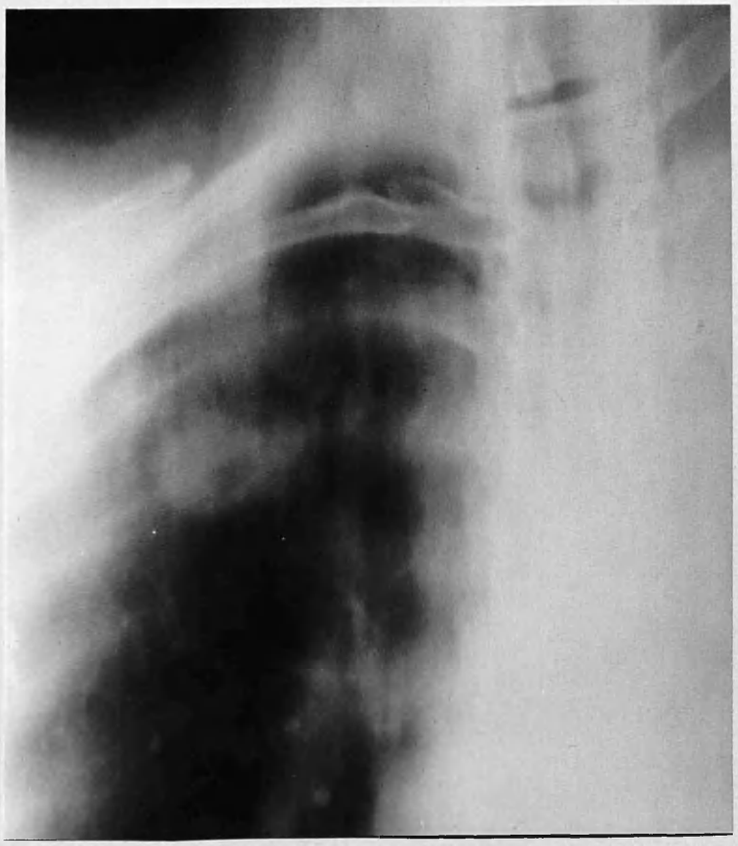


Fig. 14b. - Tomogram of the right upper zone at 4cm., taken on 3.9.51. The "smudge" has now developed into a dense nodule which has an eccentric area of clearing suggestive of early cavitation.

CASE NO. 14.

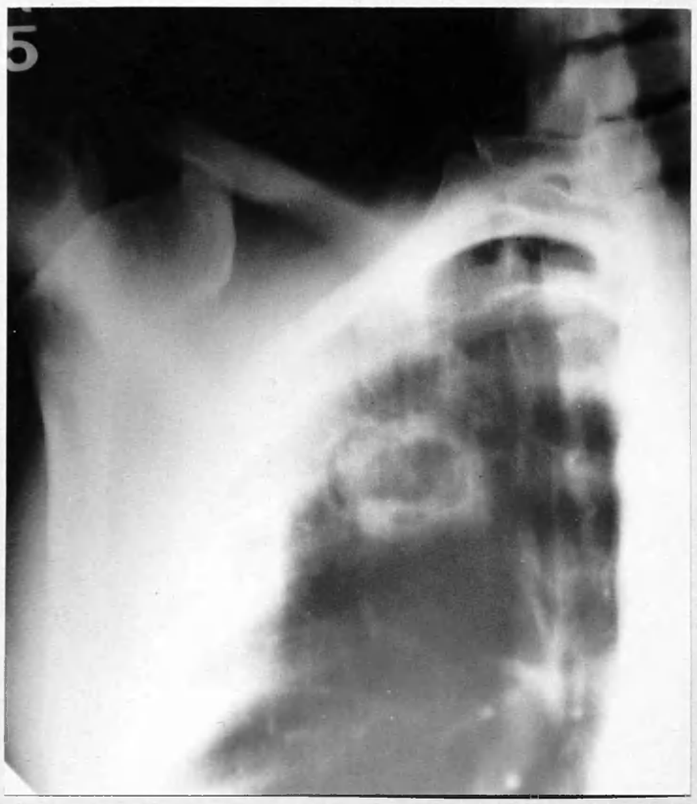


Fig. 14c. - Tomogram of the right upper zone at 5cm., taken on 1.12.52. The focus seen in Fig. 14 b. is now almost completely excavated.

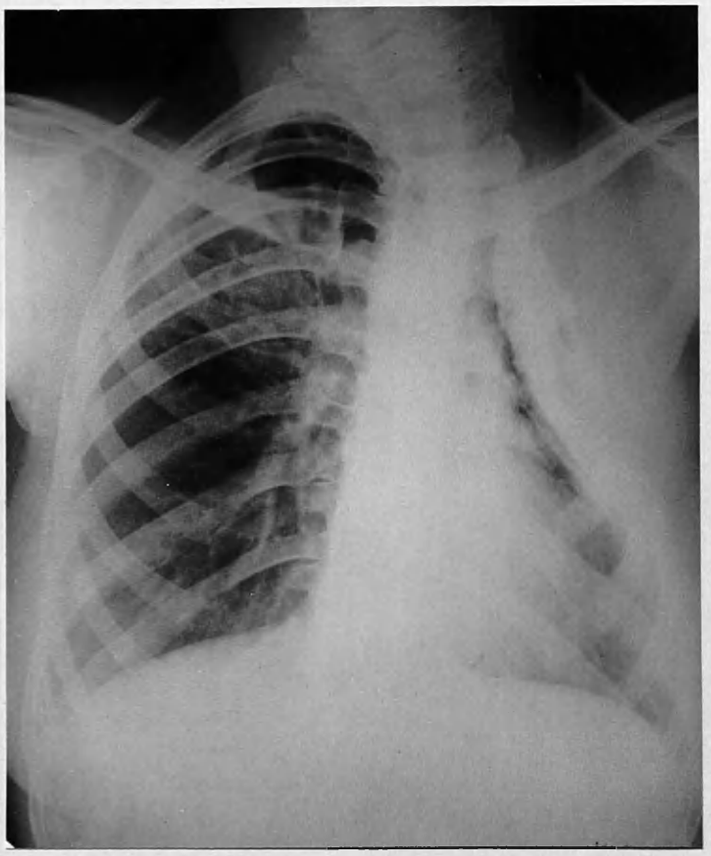
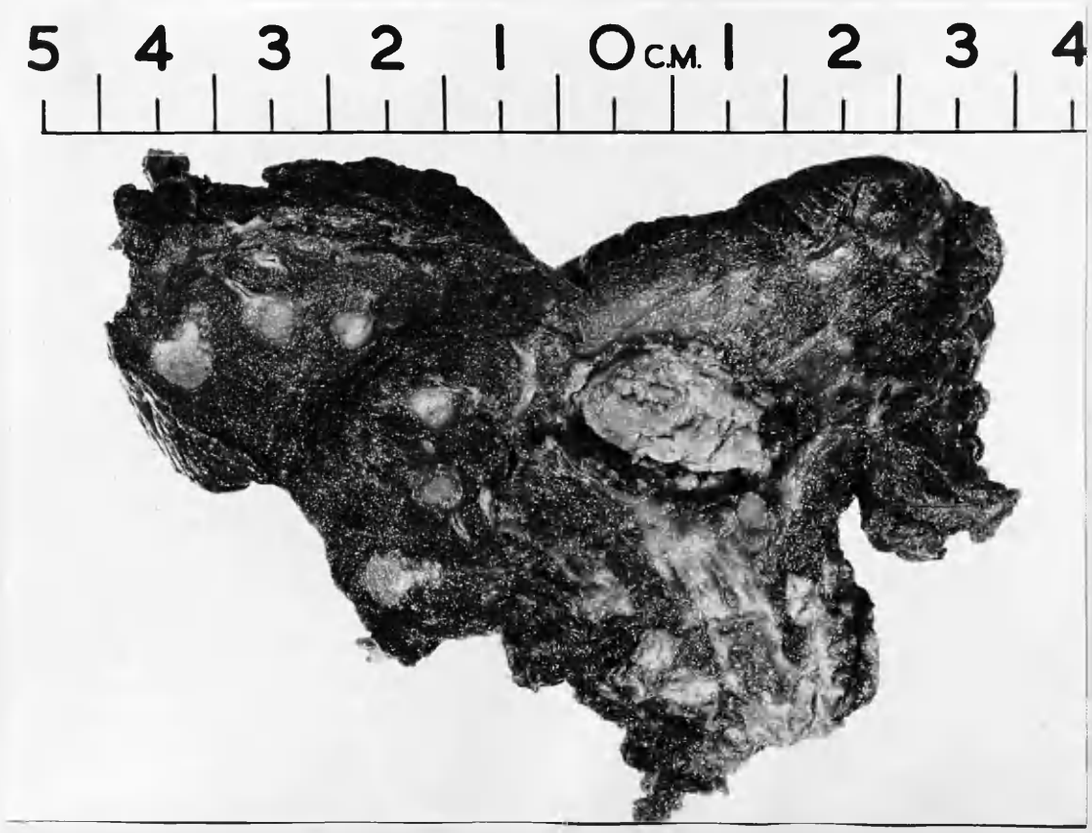


Fig. 14d. - Radiograph taken on 31.12.52. There has been a bronchogenic spread of the disease, as seen by the diffuse shadowing in the right upper and mid-zones. The cavity is clearly visible in the first intercostal space.



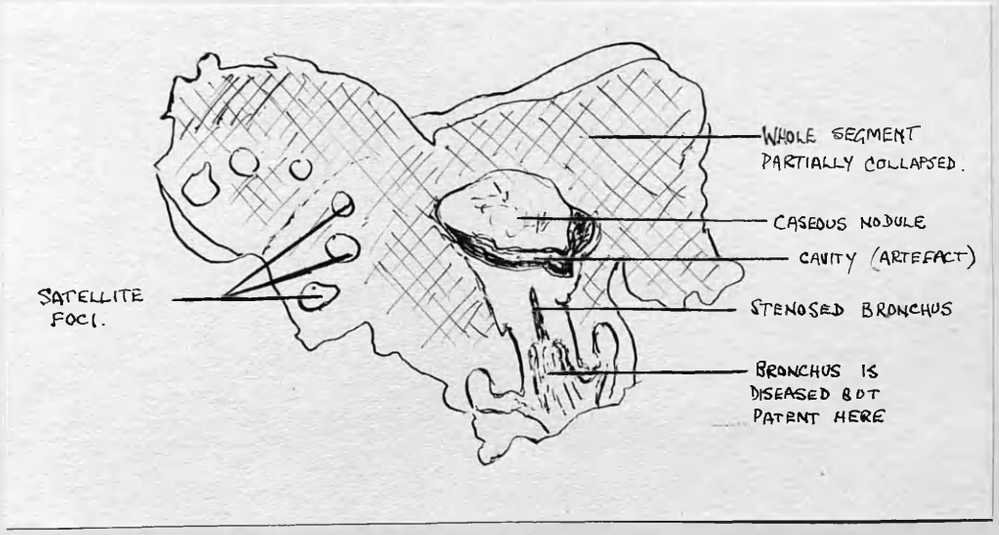


Fig. 14e. - The resected specimen.

CASE NO. 15.

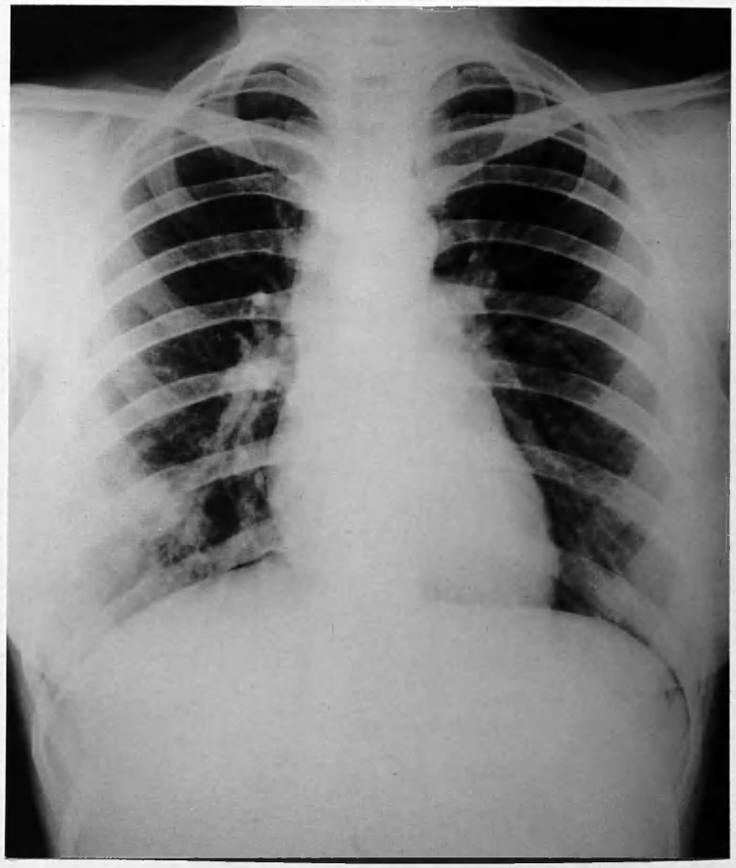


Fig. 15a. - The diagnostic radiograph taken on 15.4.52. There is fairly extensive "soft" shadowing in the right mid- and lower zones with a possible cavity in the fifth inter-costal space anteriorly.

Fig. 15b. - Tomogram through the right lower zone at 4cm., taken on 6.8.52. A nodule can now be seen in which there is an area of translucency. This is probably a blocked cavity.

CASE NO. 15.

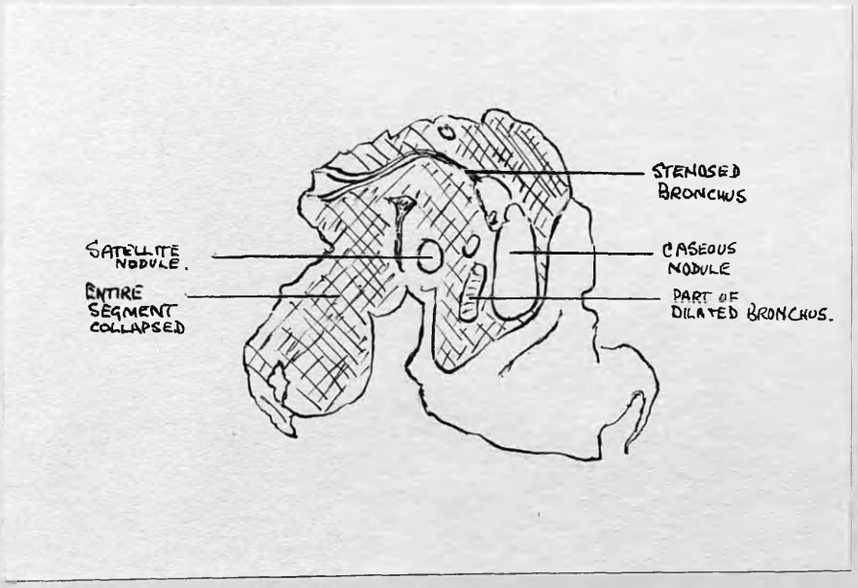


Fig. 15c. - The resected specimen.

CASE NO. 16.

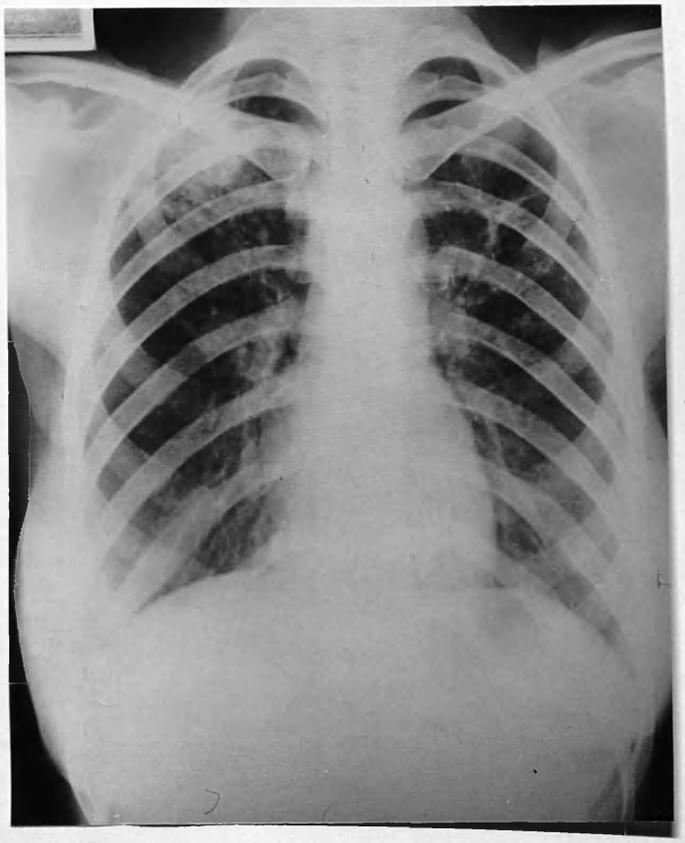


Fig. 16a. - Radiograph taken on 15.9.52., when the disease was first diagnosed. There is ill-defined "soft" shadowing in the right upper zone and also a streaky opacity in the left first intercostal space.

Fig. 16b. - Right lateral tomogram taken at the same time, showing that the posterior segment is collapsed.

CASE NO. 16.

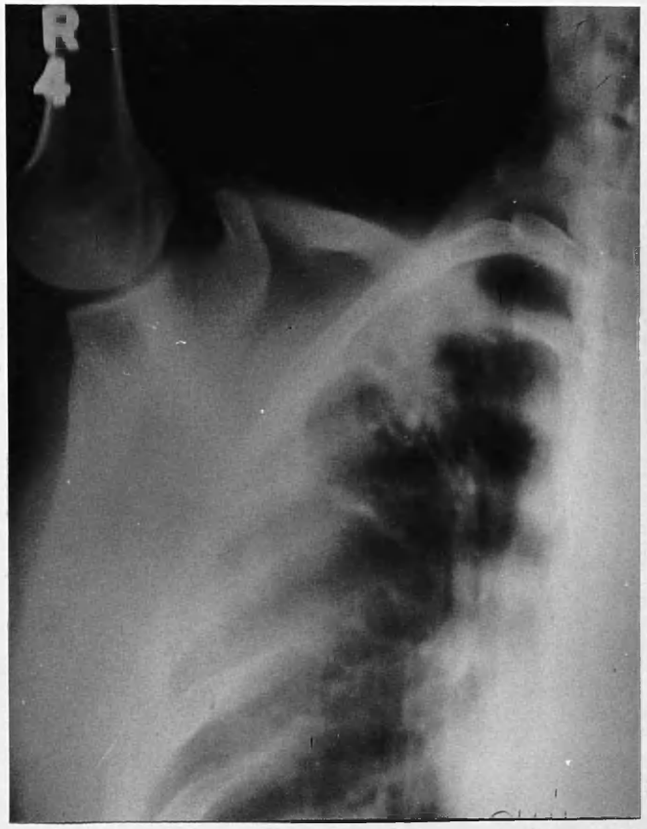


Fig. 16c. - Tomogram of the right upper zone at 4cm. depth, taken on1.4.53. There is now a nodular focus present which is partly calcified. Some vague shadowing can be seen distal to it and there are well-marked "tramlines" running from the nodule towards the hilum.

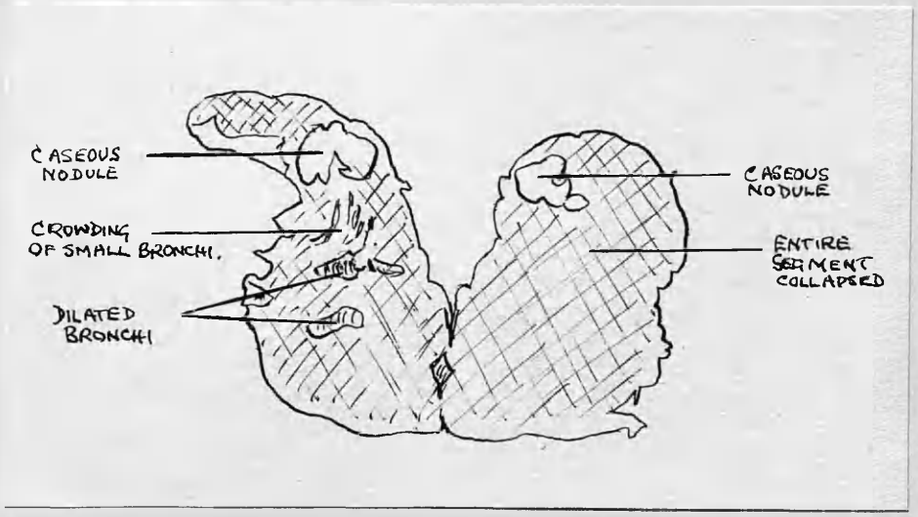


Fig. 16d. - The resected specimen.

CASE NO. 17.

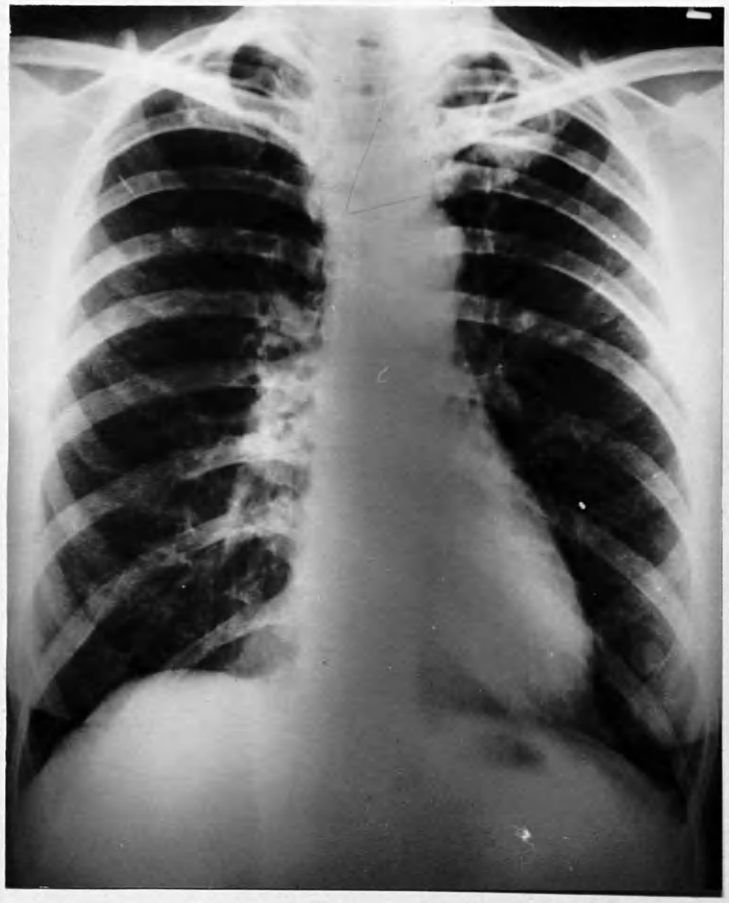


Fig. 17a. - Radiograph taken on 16.12.52. In the left upper zone behind the clavicle there is a thin-walled cavity containing a fluid level.

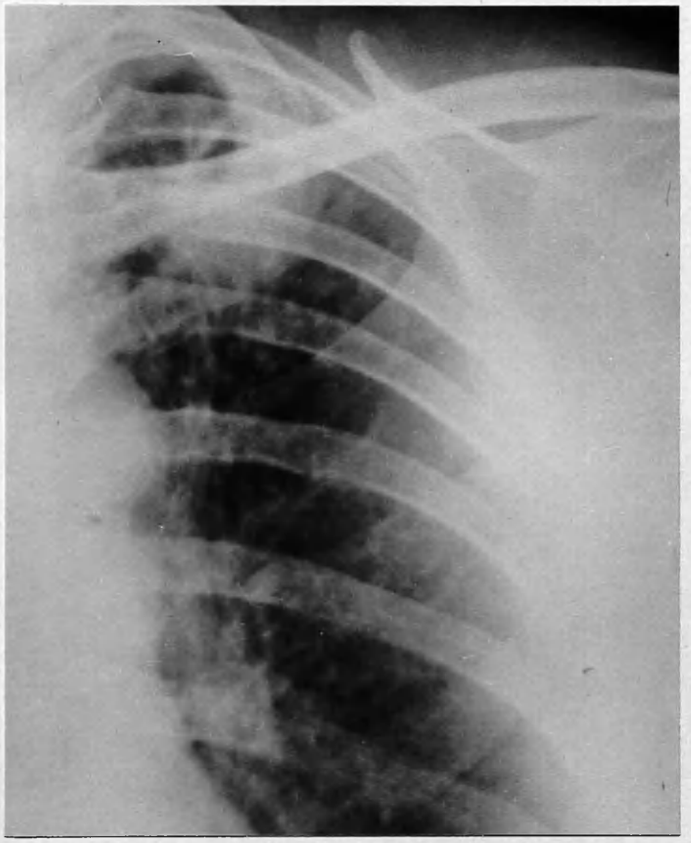


Fig. 17b. - The left upper quarter of a radiograph taken on 21.1.53. The fluid level within the cavity is higher.

CASE NO. 17.

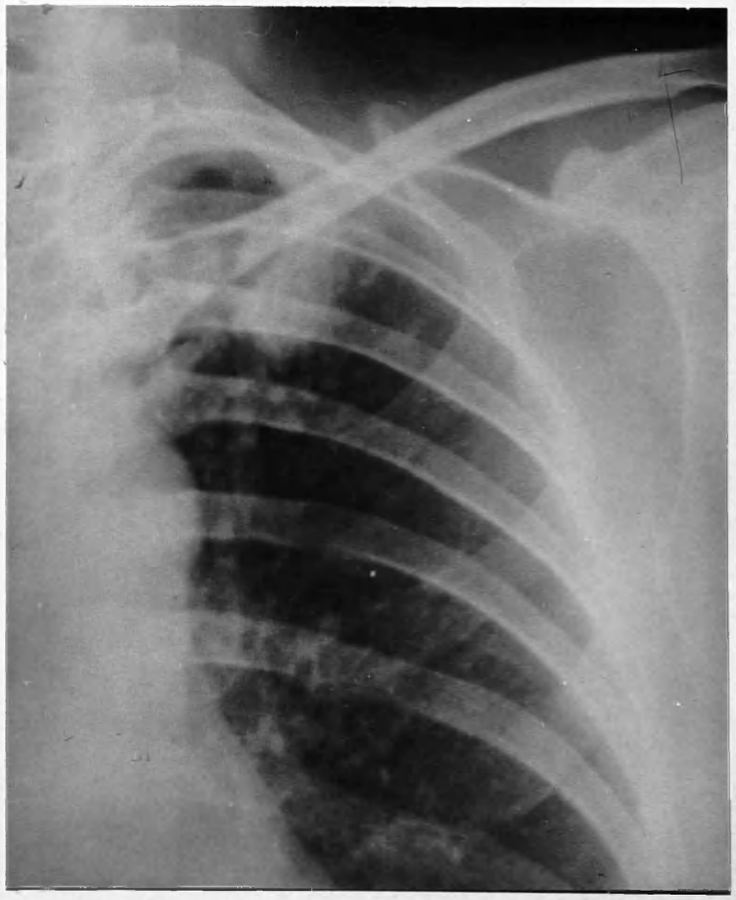
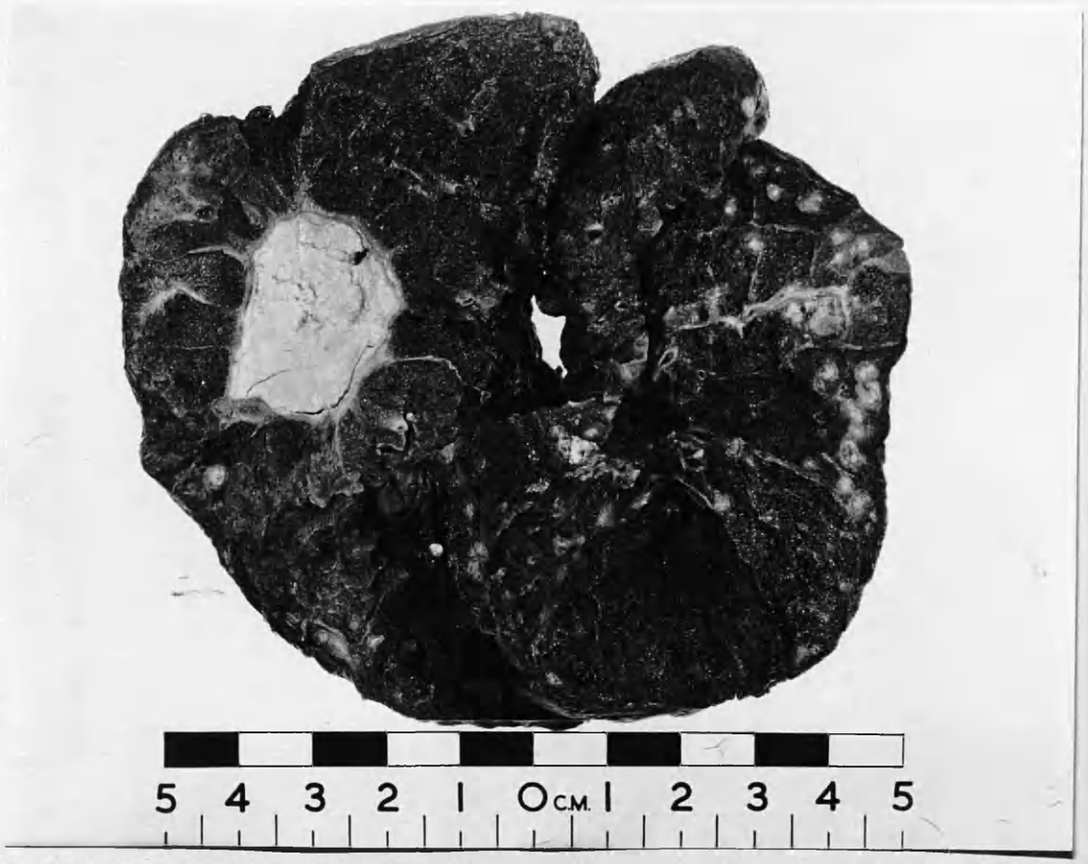


Fig. 17c. - The left upper quarter of a radiograph taken on 10.4.53. The cavity is now replaced by a homogeneous opacity.

Fig. 17d. - Tomogram of the left upper zone at 7cm., taken on 22.4.53., confirming that the cavity has "blocked." There are faint "tramlines" running towards the hilum. It is impossible to distinguish this lesion from other types of caseous nodules unless reference is made to the preceding radiographs, illustrating the process of "blocking."



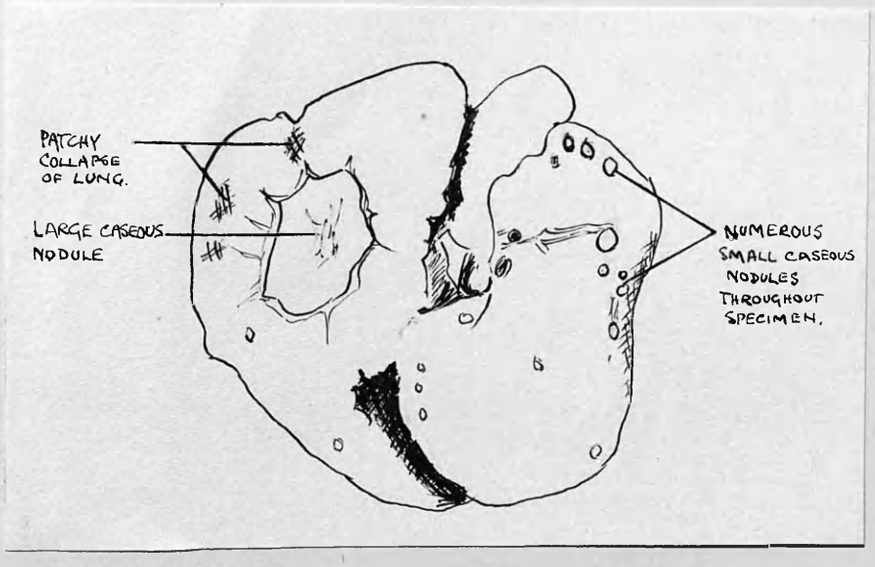


Fig. 17e. - The resected specimen.

CASE NO. 18.

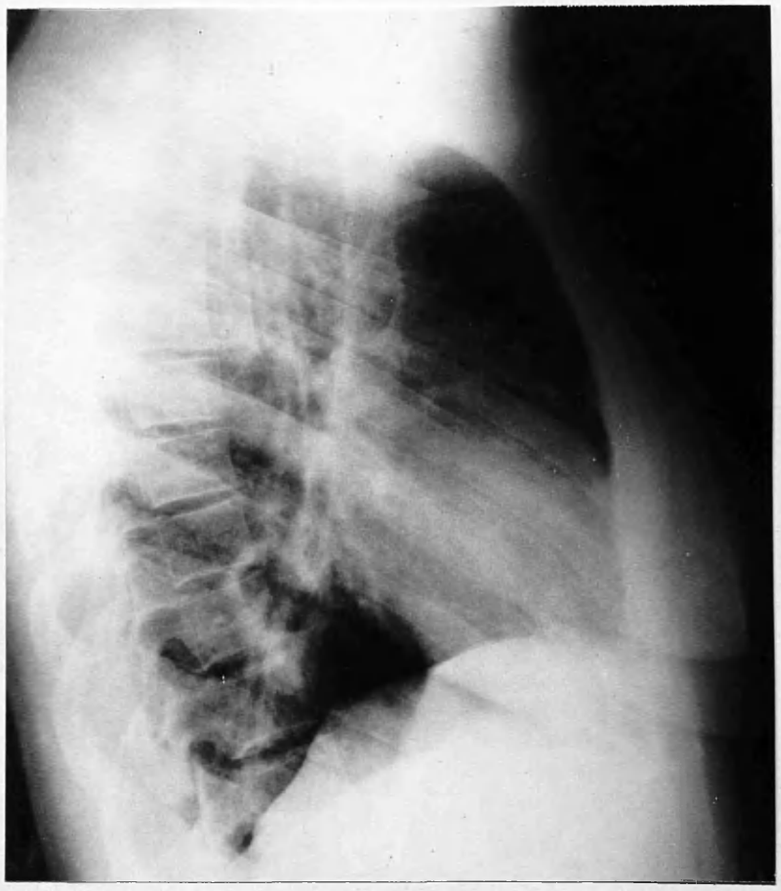
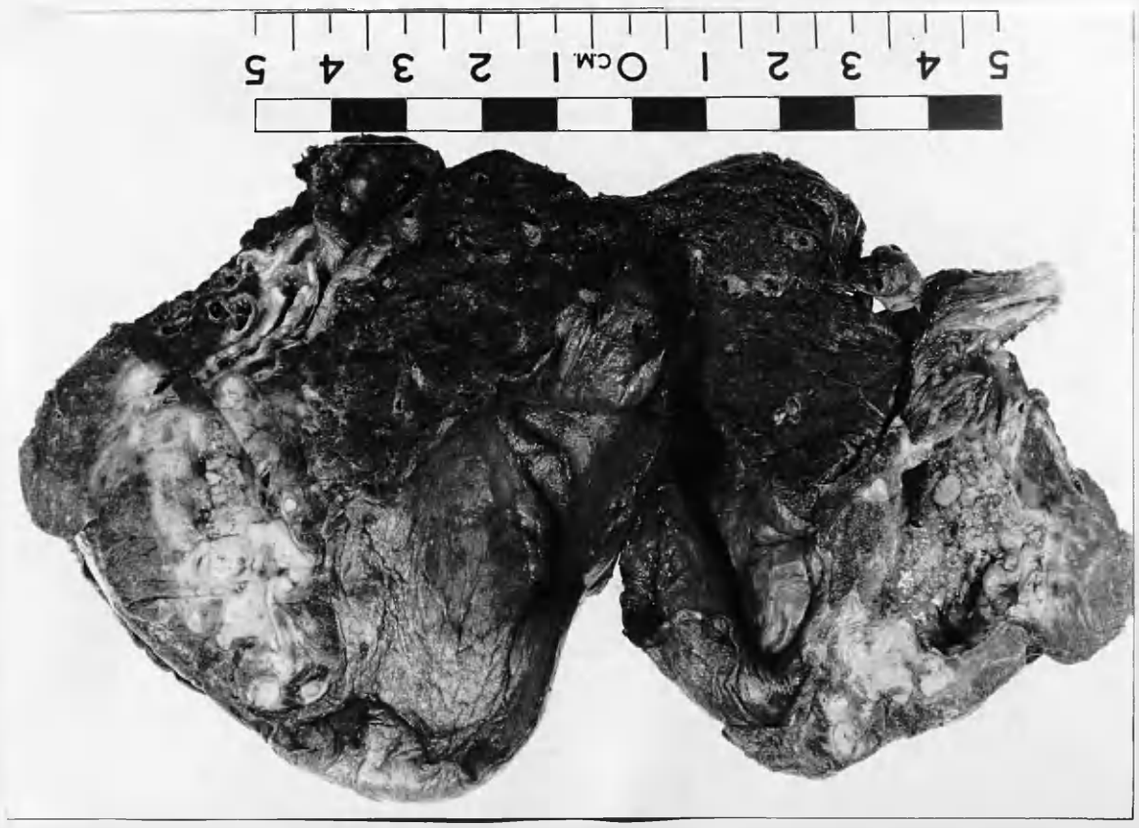


Fig. 18a. - Right lateral radiograph taken on 10.11.52. There is a large cavity in the lateral basal segment of the right lower lobe.

Fig. 18b. - Right lateral tomogram at 8cm. depth, taken on 10.5.53. In the lateral basal segment there is a solid opacity with a well-marked translucency. This has replaced the cavity seen in Fig. 18a. Behind the opacity there is a linear area of atelectasis.

CASE NO. 18.



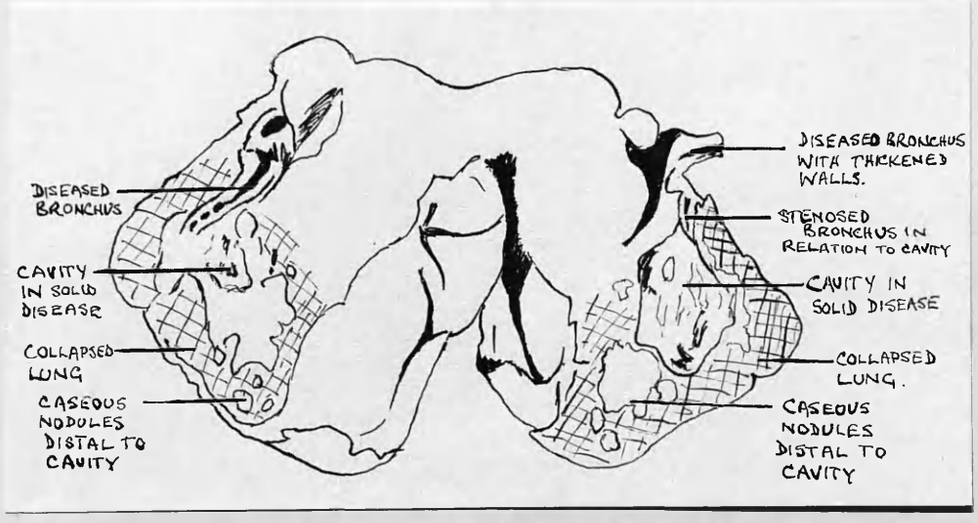


Fig. 18c. - The surgical specimen.

CASE NO. 19.

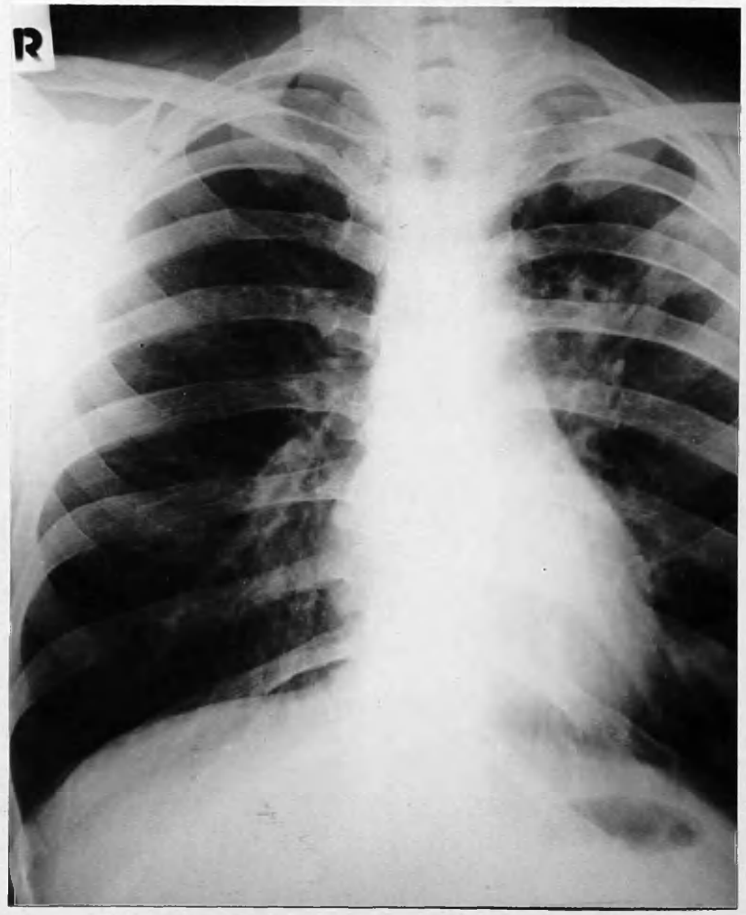


Fig. 19a. - Radiograph taken on 18.11.52. A thick-walled cavity is present in the left upper zone with "tramlines" running thence to hilum.

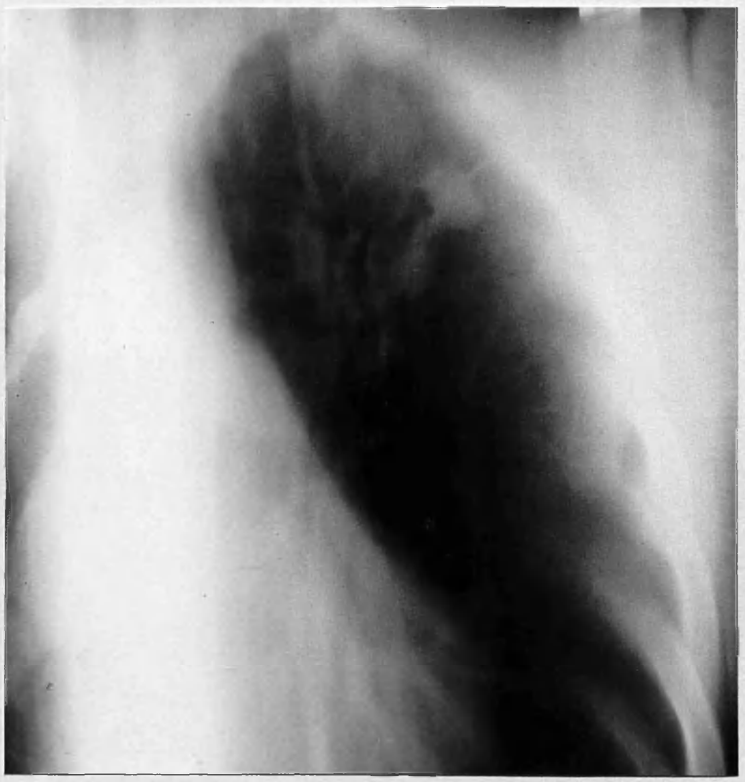
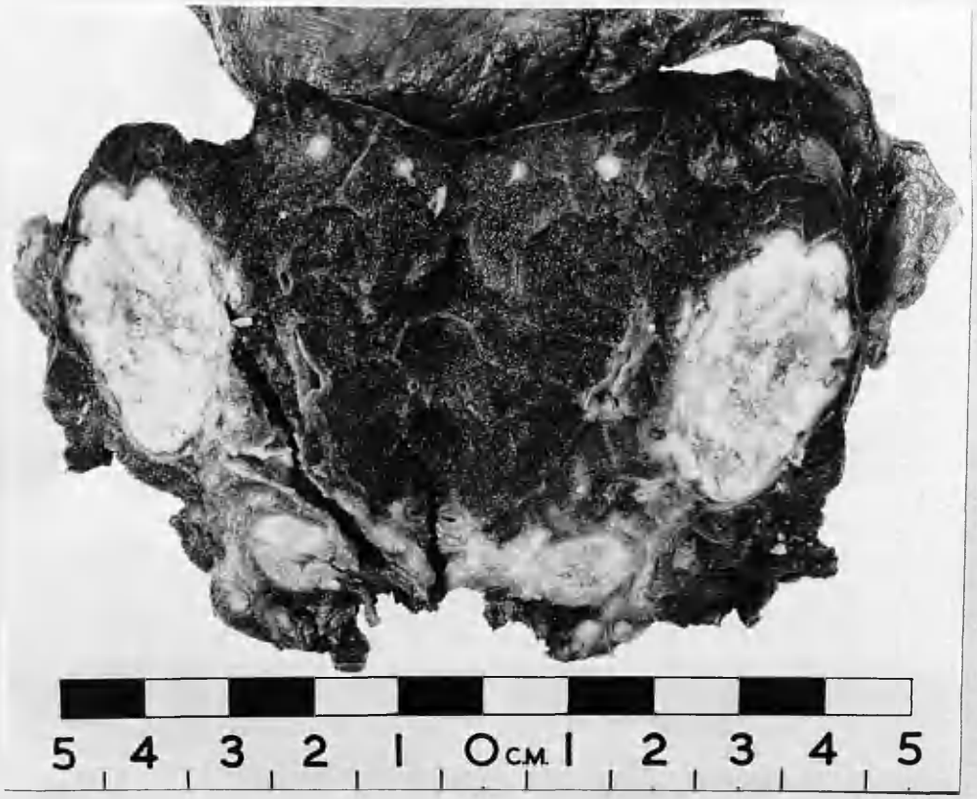


Fig. 19b. - Tomogram through the left upper zone at 9cm. depth, taken on 21.2.53. The cavity has been replaced by a dumbell-shaped opacity. There is a linear shadow of atelectasis distal to this opacity. Note also the bronchial disease as shown by the clearly defined "tramlines."

CASE NO. 19.

Fig. 19c. - Tomogram of the left upper zone 10cm., taken on 9.4.53. The focus appears to have enlarged and is round again. There is definite evidence of cavitation within it and the bronchial disease also seems to have advanced. This is the last tomogram taken before operation but a postero-anterior radiograph (not reproduced) taken on 7.7.53. suggests that the cavity has once more "blocked" and is completely solid.



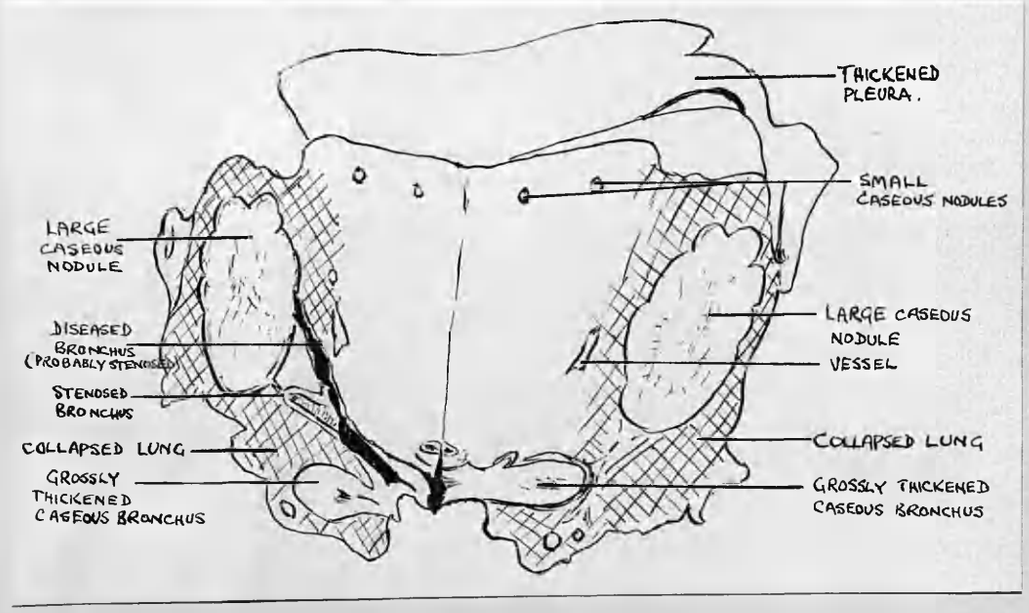


Fig. 19d. - The excised segments.

CASE NO. 20.

Fig. 20a. - Tomogram of the right upper zone at 6cm., taken on 22.7.51., showing a more or less homogeneous, solid nodule.

Fig. 20b. - Tomogram at the same depth, taken on 17.4.53. There is now a cavity replacing the nodule.

Fig. 20c. - A further tomogram also at 6cm., taken on 5.6.53. The cavity appears to have "blocked" and in its place is a nodular shadow with an area of translucency situated in its inner half.

CASE NO. 20.

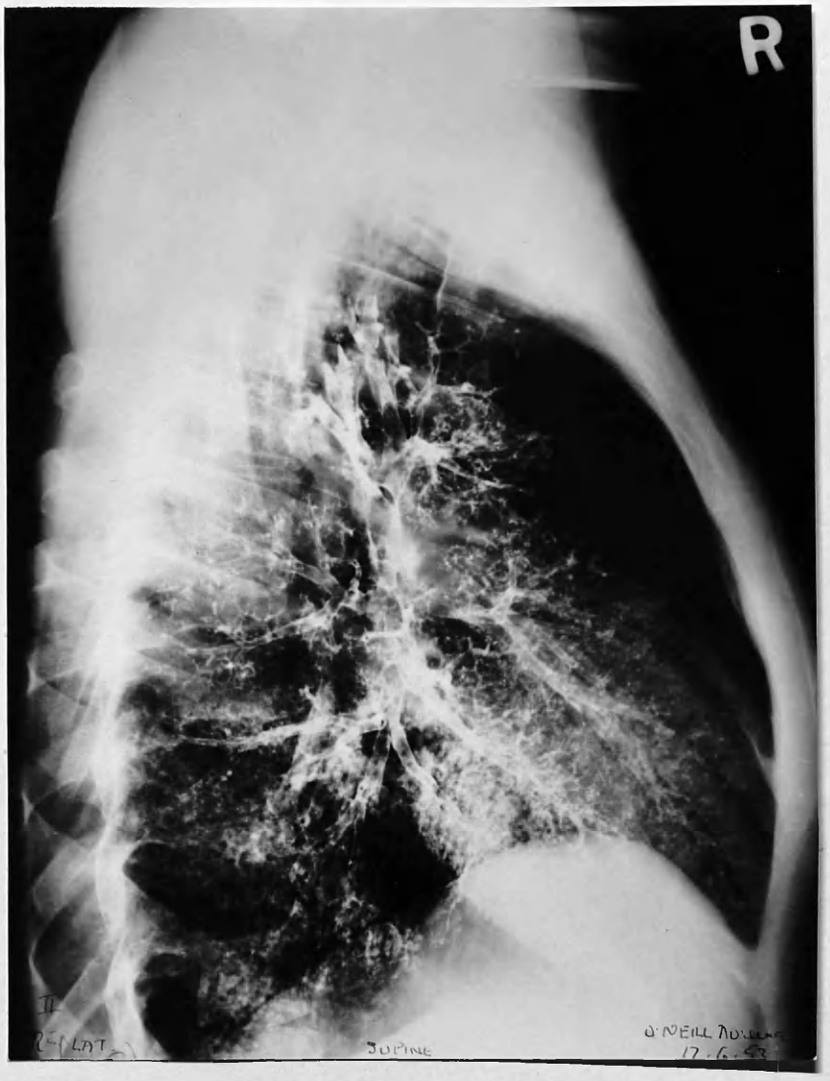
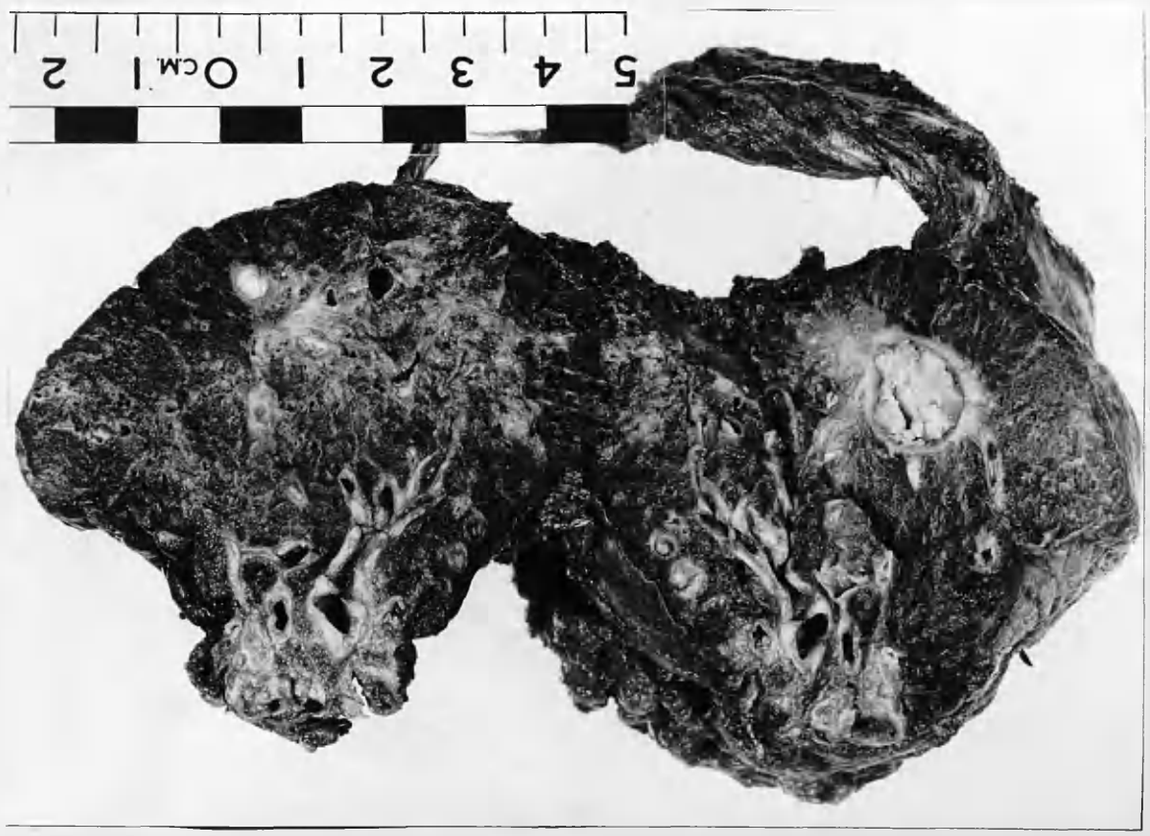


Fig. 20d. - Lateral view of a right bronchogram, taken on 17.6.53. The apical and posterior segmental bronchi are crowded together suggesting some degree of collapse of these segments, in which it will also be noted, there is no bronchiolar or alveolar filling.



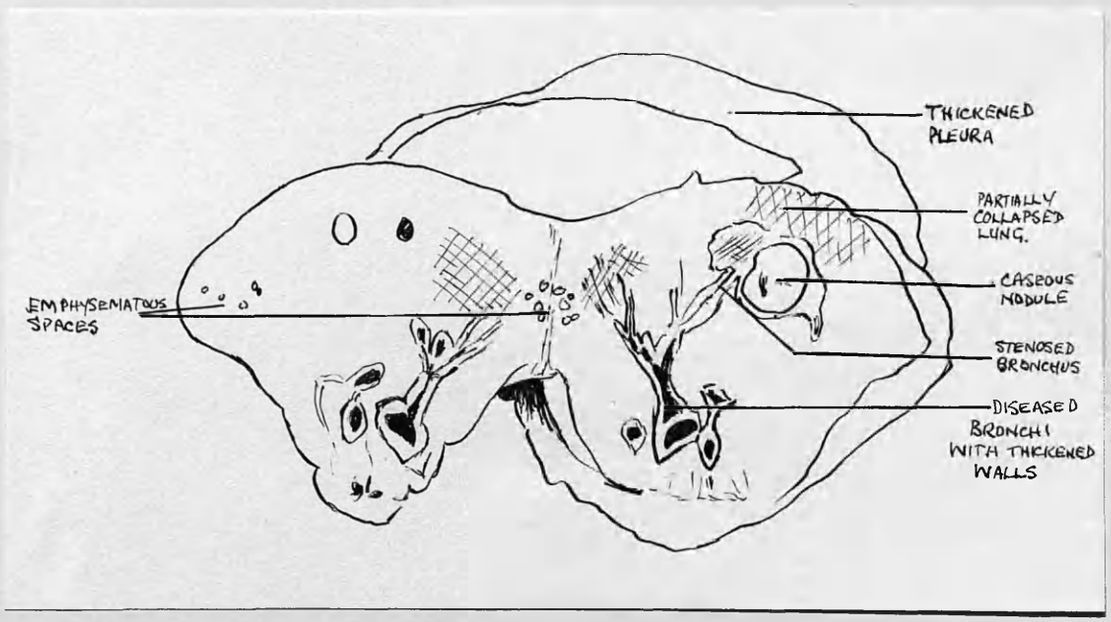


Fig. 20e. - The resected right upper lobe.

CASE NO. 21.

Fig. 21a. - The diagnostic radiograph taken on 17.12.52. There is a localised, "fluffy" shadow in the right lower zone.

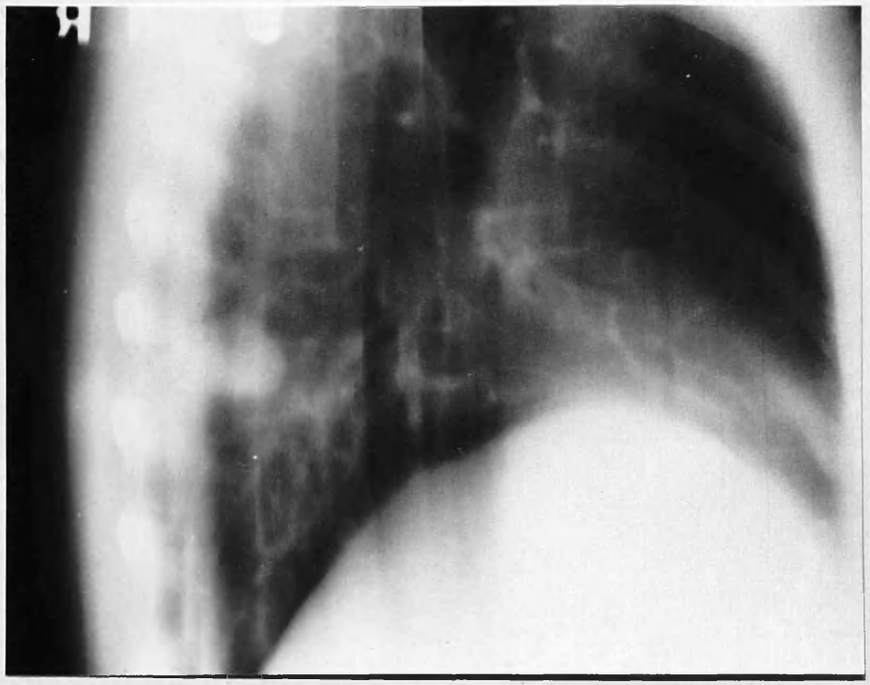


Fig. 21b. - Right lateral tomogram at 8cm., taken on 10.4.53., showing that a dense round focus has developed from the "fluffy" shadow seen in Fig. 21a., and is situated posteriorly, probably in the subapical segment of the lower lobe.

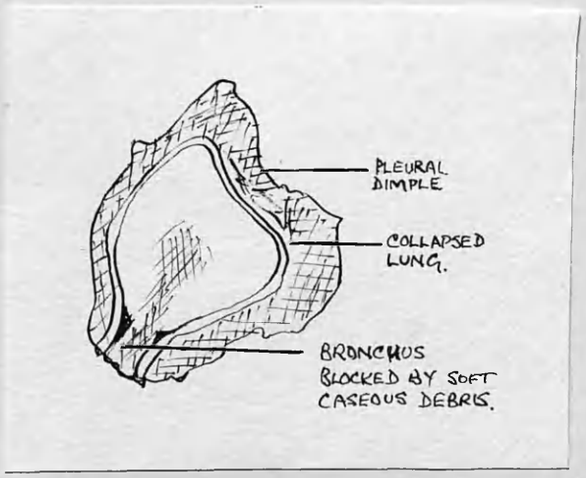


Fig. 21c. - The resected focus.

CASE NO. 22.

Fig. 22a. - Tomogram of the right mid-zone at 2cm., taken on 1.8.51., showing a thick-walled cavity in the apical segment of the lower lobe.

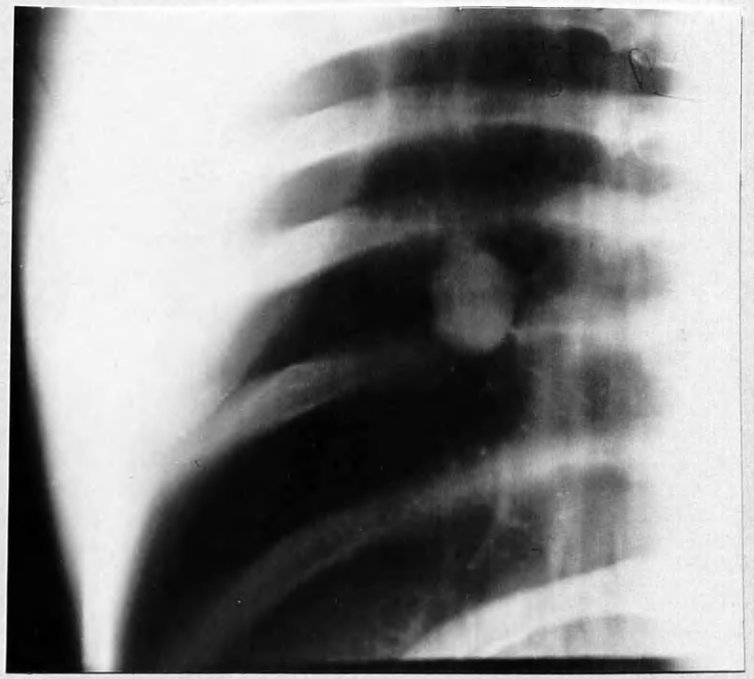


Fig. 22b. - Tomogram of the same area at $2\frac{1}{2}$cm., taken on 19.6.53. The cavity has been replaced by a homogeneous opacity, radiologically indistinguishable from other types of caseous nodules.

CASE NO. 22.

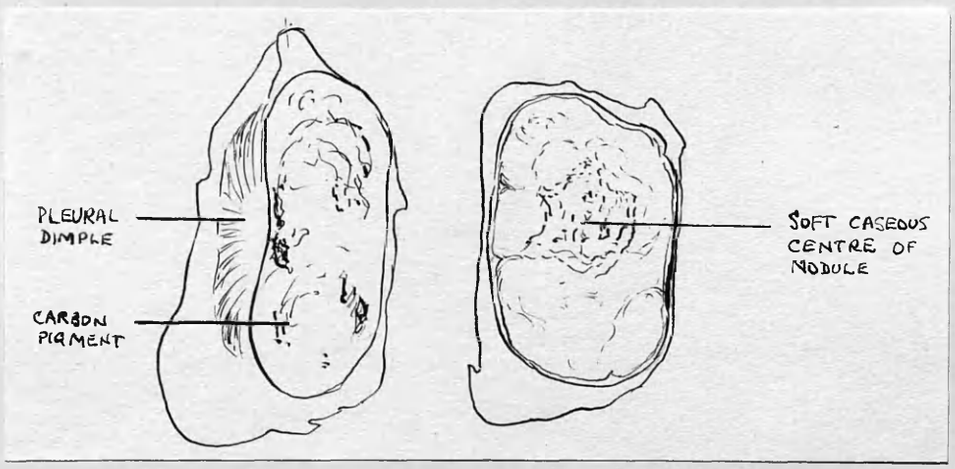


Fig. 22c. - The nodule.

CASE NO. 23.

Fig. 23a. - Tomogram of the left upper zone at 5cm., taken on 11.6.52., showing a homogeneous triangular opacity.

Fig. 23b. - Similar tomogram taken on 11.2.53., in which the opacity is larger and there is now a slightly eccentric area of translucency.

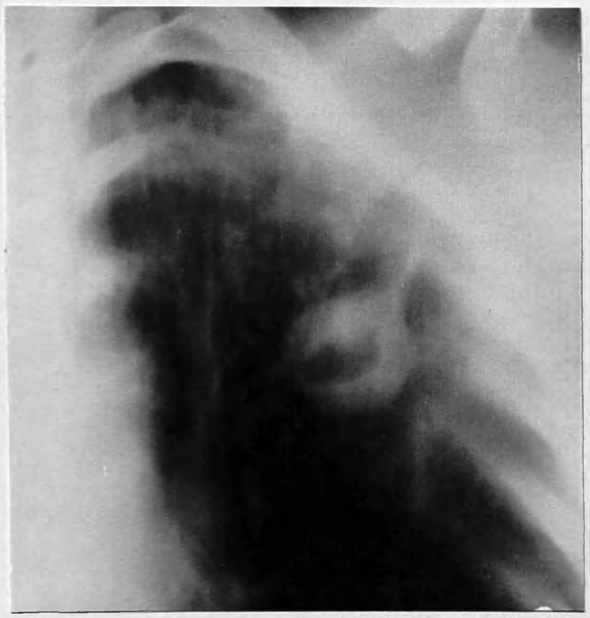


Fig. 23c. - A further tomogram of the left upper zone, taken on 1.6.53. Enlargement of the lesion has progressed and cavitation is more definite

CASE NO. 23.

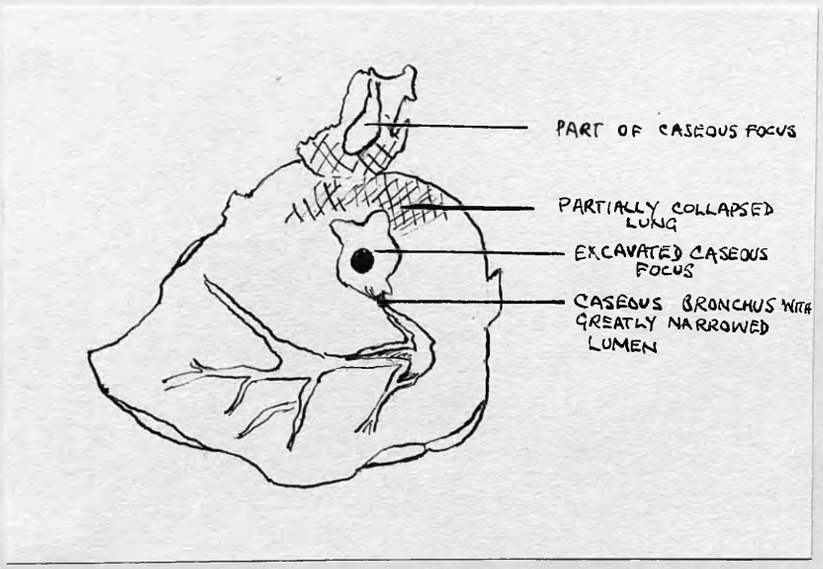


Fig. 23d. - The specimen.

CASE NO. 24.

Fig. 24a. - Tomogram of the left mid-zone, taken on 1.4.53. A round focus is present, in the medial part of which there is a possible cavity. The latter may be in communication with a bronchial lumen, contained within rather faint "tramlines." Distal to the round focus a small linear shadow of atelectasis can just be made out, and above it there is the hazy shadow of a satellite focus in a slightly posterior plane.

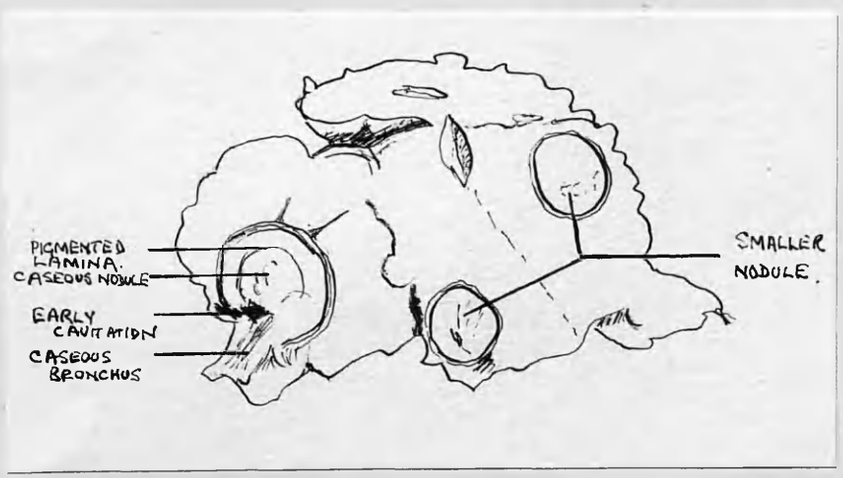


Fig. 24b. - The resection specimen.

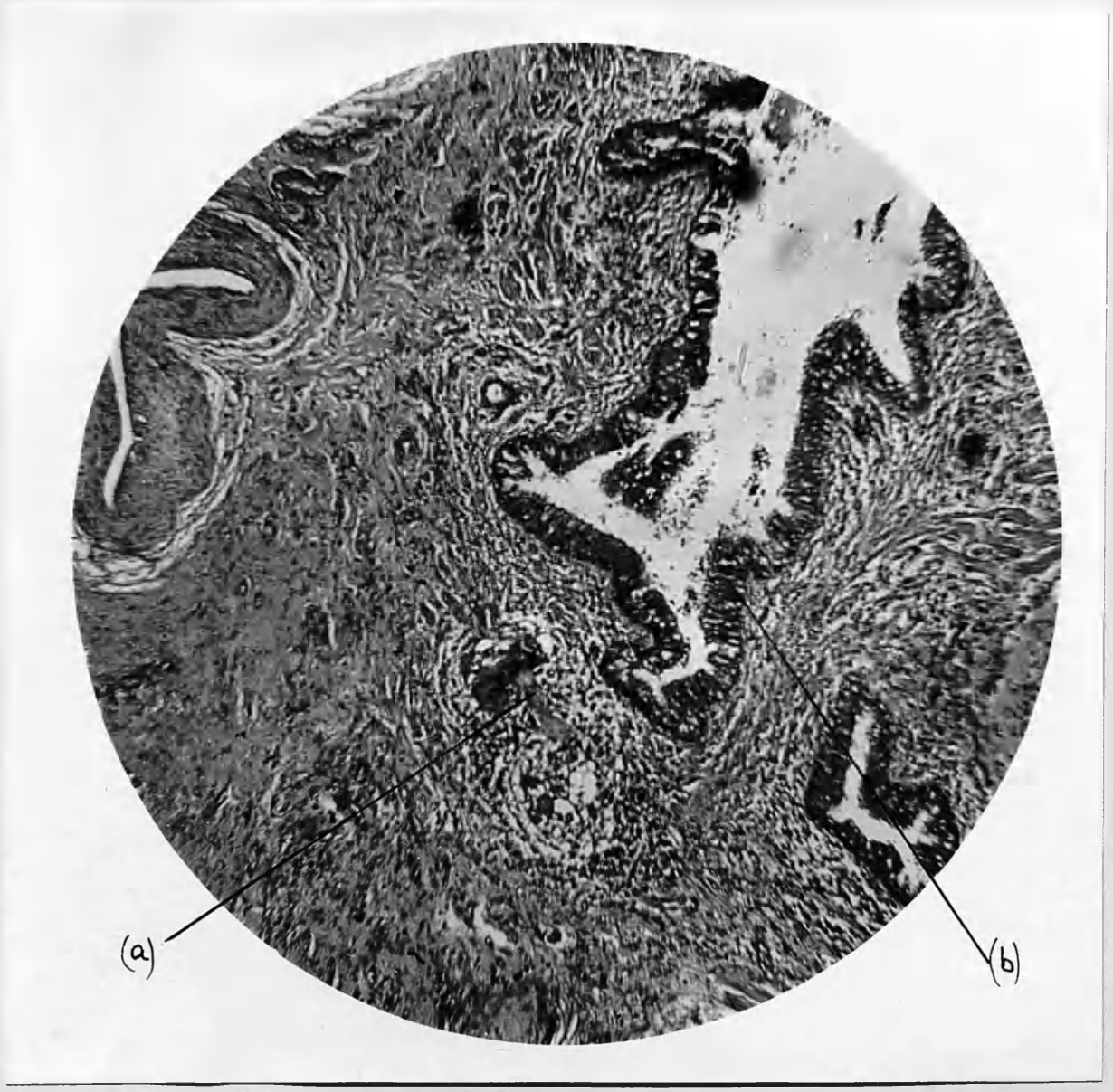


Fig. 25. - Photomicrograph of a section stained with haematoxylin and eosin (x 240). There is a subepithelial tubercle (a) in the wall of a small bronchus. The epithelium lining the bronchial lumen (b) is normal.

Fig. 26. - Photomicrograph of a section stained with haematoxylin and eosin (x 240). Giant cell systems of tuberculosis are present in lymphatics related to small vessels and bronchi. The surrounding lung is emphysematous.

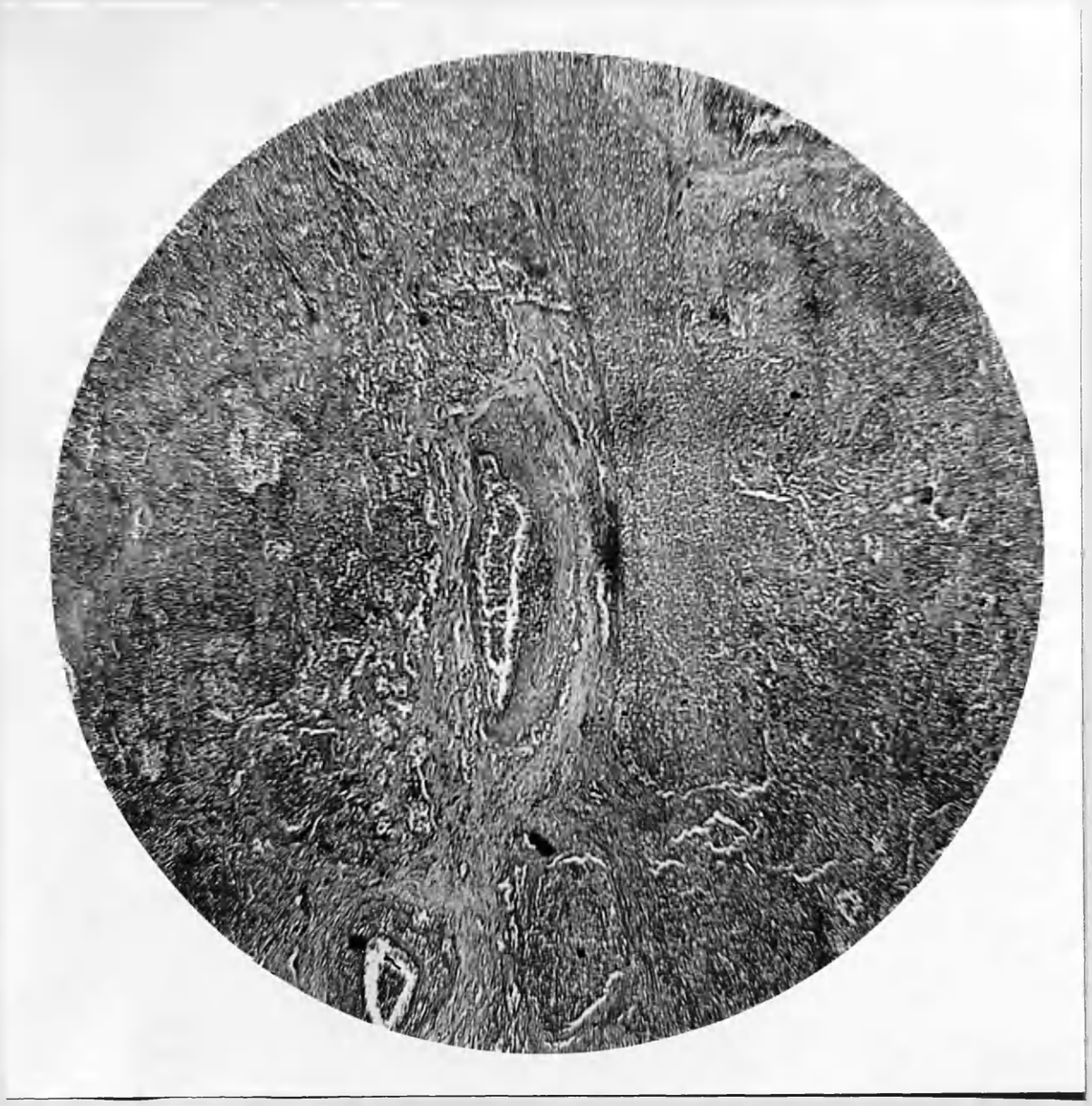


Fig. 27. - Photomicrograph of a section of a caseous nodule stained with haematoxylin and eosin (x 40). The section shows an area of caseous pneumonitis in which complete progression to amorphous caseous debris has not yet occurred.

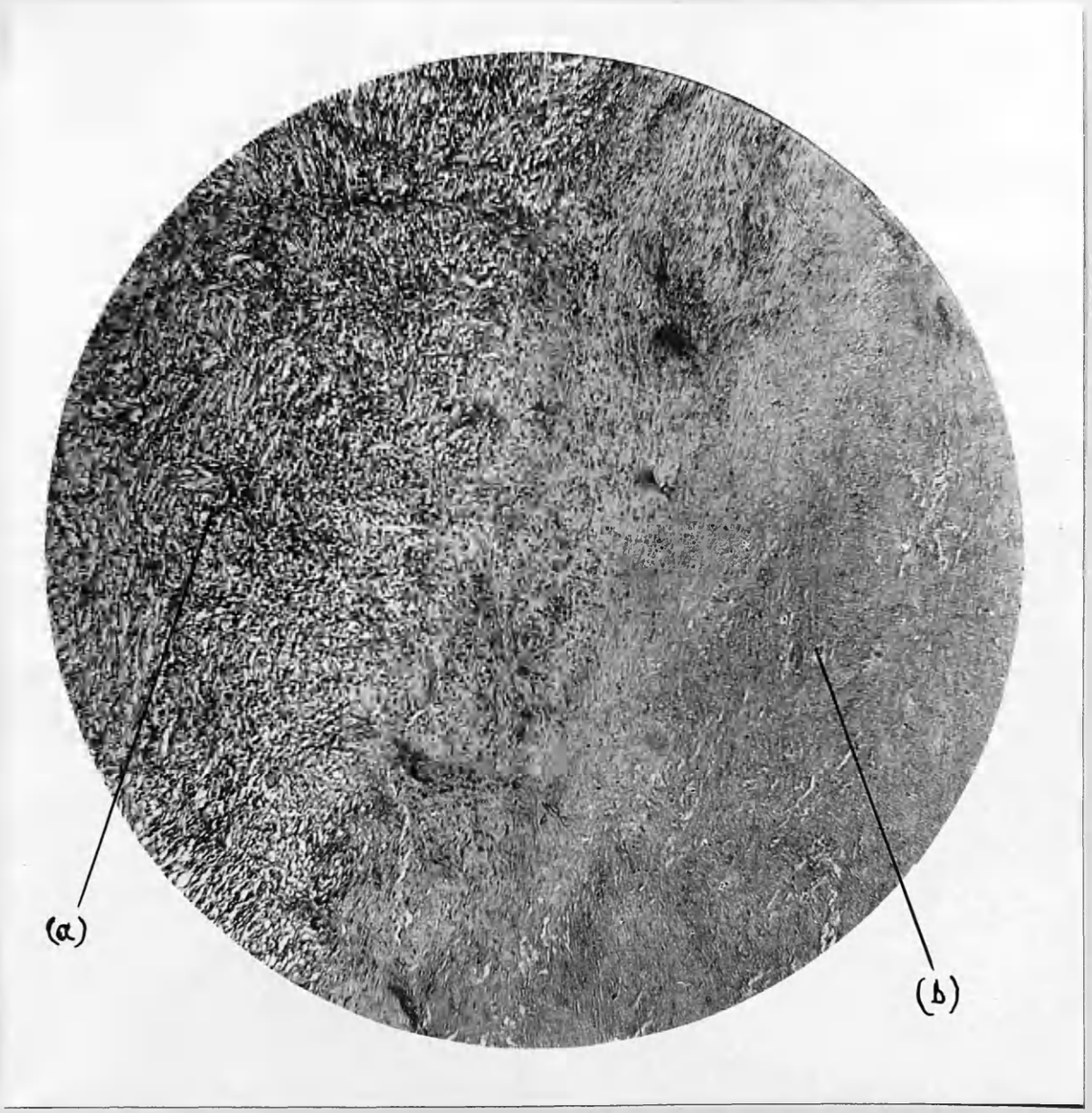


Fig. 28. - Photomicrograph of a section of a caseous nodule stained with haematoxylin and eason (x 240.) The transition from pneumonitis (a) in which there is some conservation of structure into amorphous caseous material (b) is well shown.

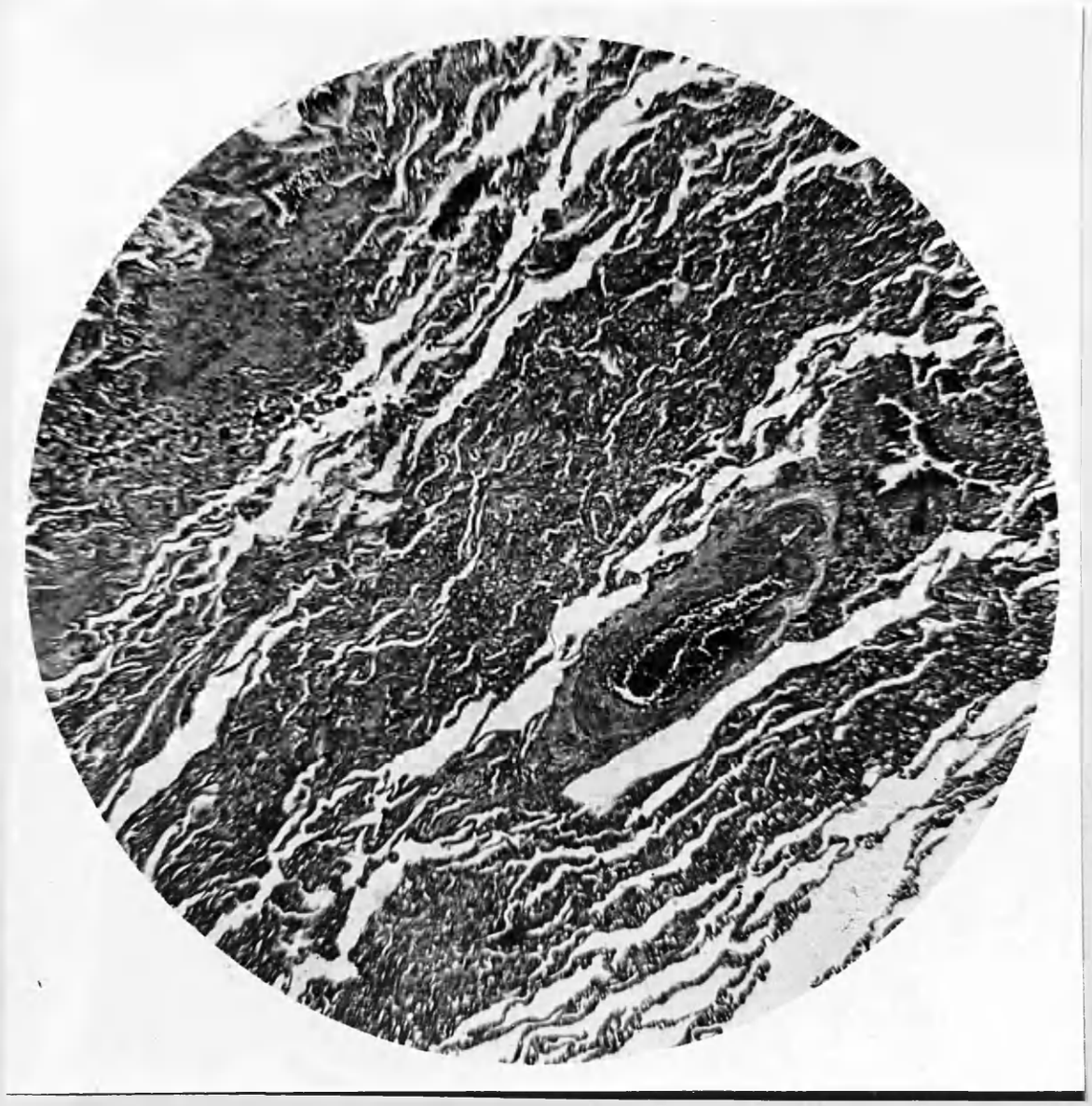


Fig. 29. - Photomicrograph of a section stained with haematoxylin and eosin (x 40). The section shows an area of collapsed lung such as is usually found distal to caseous nodules. The collapse is indistinguishable from collapse caused by other pathological conditions except sometimes when tubercles may be found within it.